40TH ANNUAL CONFERENCE REPORT ON COTTON INSECT RESEARCH AND CONTROL

E. G. King, J. R. Phillips, and R. B. Head
Research Entomologist, Professor,
and Extension Entomologist, respectively
Southern Field Crop Insect Management Laboratory
USDA, ARS, Stoneville, MS
Entomology Department, University of Arkansas
Fayetteville, AR and
Mississippi Cooperative Extension Service
Mississippi State University, MS respectively

[1986]

Foreword

The format for the 40th Annual Report is the same as that used for the 38th and 39th, which was approved by conferees in 1984. In this format the annual report is limited to: (1) a summary of the 1985 insect and crop conditions by state; (2) an insect losses statement; (3) changes in pesticides registration; (4) recent insect control recommendations since the 37th Annual Conference Report; (5) a listing of promising new pesticides; and (6) a brief summary of significant research accomplishments and progress in on-going research projects by state and federal organizations.

There were 9,270,502 acres of cotton harvested in 1986 with an average yield of 1.06 bales/acre or a total of 9,826,732 bales. The bollworm (BW), Heliothis zea (Boddie), and the tobacco budworm (TBW), H. virescens (F.), were the most damaging pests followed by the boll weevil, Anthonomus grandis Boheman, and plant bugs. Arthropod pests reduced yield by an estimated 7.76% in spite of the best control measures with an estimated $219,282,688 lost. The cost per acre for controlling arthropod pests was $24.70 for an estimated total of $228,981,350. So, total estimated costs of arthropod pests to cotton production approached one-half billion dollars in the USA in 1986.

Crop and Arthropod Pest Conditions

Alabama. Seedling emergence and development was delayed by severe drought. Drought conditions were widespread in southeastern Alabama throughout the season and moisture was variable for the remainder of the state. Yields were variable ranging from zero (abandonment) to two bales per acre. Average yield was 500 lb lint/acre.

Thrips populations were again high on seedling cotton. Moreover, the species changed. Systemic insecticides were used extensively for thrips control. Disulfoton was used most often because aldicarb was in limited supply. Additionally, insecticide foliar sprays were applied ($\bar{x}$ = 1.75 applications/acre).

Other insect problems included the boll weevil; yellowstriped armyworm, Spodoptera ornithogalli (Guenee); plant bugs; Heliothis spp.; beet armyworm, S. exigua (Hubner); soybean looper, Pseudoplusia includens (Walker); and cabbage looper, Trichoplusia ni Hubner. Boll weevil populations were high and widely distributed. Numerous applications were made for control of overwintered weevils, but subsequent populations remained high throughout the season. Yellowstriped armyworm populations caused foliage and terminal damage in June in north Alabama.

Plant bug populations were less than normal, but where problems did exist, it was due to migratory adults. TBW populations were slightly higher than average, particularly in June, and these populations were not suppressed to an acceptable level.

The twospotted spider mite, Tetranychus urticae Koch, and the cotton aphid, Aphis gossypii Glover, were widespread problem pests. There was a linkage between occurrence of these pests and the use of pyrethroids. High mite infestations occurred in North Alabama in late May and June (this is unusually early), and undulating populations continued to create problems in many areas throughout the season. These populations were typically controlled by applications of chlorpyrifos and monocrotophos. Monocrotophos was apparently effective against hatching eggs, and rebounding mite populations caused a shift back to the use of this material.

In North Alabama, failures to control aphids with numerous products were noted (lb/acre): chlorpyrifos (up to .5); dicrotophos (up to .267); monocrotophos (up to .75). In fact, methyl parathion applied at the rate of .33 lb (A.I.)/acre was as effective as other materials. Because control of aphids with chemicals was ineffective, these populations often resurged.

Another pest identified in 1986 was Frankliniella occidentalis (Pergande), western flower thrips. Epidemic populations occurred during mid-season across the state, but these populations seem to be most heavily concentrated in areas of high insecticide use. Insecticide applications were typically ineffective in reducing populations of the western flower thrips, however, control attempts for this apparent pest were uncommon. Stoppage of boll growth ("freezing") was associated with western flower thrips populations, and this damage was apparently caused by thrips feeding on or near the peduncle. A sunken lesion running from the base of the peduncle down the stem was associated with the injury.

Arizona. Pectinophora gossypiella (Saunders), pink bollworm (PBW), was the most wide-spread and damaging pest in Arizona cotton during 1986. Damaging infestations occurred two to three weeks earlier than normal and control was most difficult in the central and western cotton-producing areas.

Plant bugs, BW, and TBW were serious pests in some areas statewide but were at or below normal populations levels. Boll weevil infestations became more widespread in central Arizona causing yield reductions and increased control costs in areas of infestation. Boll weevil populations were lower in the western Arizona eradication zone. Other sporadic pests included spider mites, whiteflies, and cotton leafperforators, Bucculatrix thurberiella Busck.

Arkansas. In the northeastern part of the state, thrips populations were high early in the growing season. Cool, wet weather retarded the growth of the cotton crop and rains prevented or washed off insecticide applications. Many fields were treated twice for thrips. Plant bug densities were low, and many unirrigated fields did not attain treatment levels. This was due, in part, to the hot, dry weather in June and July. Most irrigated fields required at least one application for plant bugs.

The boll weevil survived the mild winter in high numbers and continued to move northward during the growing season. Treatment level infestations were found north of Jonesboro in Craighead County. This represents a northward move of approximately 60 miles during the 1986 season. Pinhead square insecticide applications were effective in controlling overwintered weevils.

BW populations attained treatment levels 3 weeks earlier than normal and pressure was continuous during July and August. Populations were higher than normal. Flowering was terminated by mid-August in nonirrigated fields because of the hot, dry weather. So, moth activity was focused in irrigated fields.

In the southeastern portion of the state, insect pest pressure was greater than usual for most species. Thrips numbers were high in most fields that were not treated with an in-furrow systemic insecticide at planting. Overwintered boll weevil numbers were extremely high, apparently because of low mortality during the mild winter. Many boll weevil pheromone traps averaged over 100 weevils per trap the week before pinhead square. Two treatments were made during the pinhead square plant growth stage on 95%, or more, of the cotton acreage in southeastern Arkansas to reduce weevil numbers. Consequently, plant bug populations were also reduced. BW activity was lower than normal through June but moderate to high from early July until season end. In most cases, insecticides were applied at least weekly to suppress bollworm populations. About August 19, populations of TBW larvae developed in fields that had new growth and fruit present due to second growth or late maturity. Subsequent tests on moths developing from these larvae showed 50 to 80% of the population resistant to cypermethrin. Aphid populations were present throughout the season, and they attained treatment levels by late July and August. Resurgence of these populations was a problem and up to three treatments were applied per field.
The cotton crop matured early and defoliants were applied to many fields in late August and early September.

Reprinted from 1987 Proceedings of the Beltwide Cotton Production Research Conferences

California. Spider mites (Tetranychus spp.) and Lygus hesperus Knight were the dominant arthropod pests of cotton in the San Joaquin Valley during 1986, with localized outbreaks of beet armyworm and cabbage looper as well as scattered heavy infestations of cotton aphid. Plant bug numbers were high in some areas in response to above normal late winter rainfall and an abundance of weeds in a number of field and orchard crops. Weeds in these other crop situations apparently related to reduced herbicide use during the 1985-86 year. Spider mite outbreaks were exacerbated by the use of insecticides for control of plant bugs. Spider mite populations in areas of intensive miticide use were resistant to dicofol and propargite and, in the absence of predators, some farmers found spider mite control impossible to achieve. Outbreaks of beet armyworm and cabbage looper were apparently related to pesticide use for control of plant bugs. These pests were managed with various insecticides. Cotton aphid outbreaks occurred throughout the San Joaquin Valley and persisted from May through August. Many of these infestations were ultimately suppressed by predators although some plant stunting and yield loss was resulted. Chemical control was generally successful.

Yields for a majority of the San Joaquin Valley growers appeared to be near or slightly below normal. However, yields were moderately to severely reduced by plant bugs and spider mites in areas where these pests were severe and not effectively controlled. Yield reductions were generally near 10 to 25% and occasionally up to 60%.

Georgia. The Georgia Crop Reporting Service estimated 190,000 acres harvested. Yield in 1986 was 429 lb lint/acre, which was a 41% decline from the 1985 average.

Weather was a major factor influencing yield in Georgia during 1986. Little rain occurred during early and mid-season, and temperatures were above average. Planting dates ranged from late March into early July. Plant stands were not uniform, and much of the earlier plantings did not survive through the drought. Cotton planted during late May and June did survive because of rains occurring in mid-August.

Insect pest problems varied throughout the state. Thrips were more numerous in cotton because lack of rainfall reduced alternate host plants and there was little moisture in the soil to activate the systemic insecticides. Popula-tions of overwintered boll weevils were high. However, high temperature and drought conditions reduced these populations. Nevertheless, populations rebounded during August as growers attempted to make a late crop after the occurrence of rainfall. TBW populations were prevalent during early season and many fields were treated for this pest beginning in mid-June. Populations of TBW again became high during the last week of June and continued into July where these populations overlapped with BW populations. Consequently, there was continuous pressure by Heliothis throughout the period of mid-June into August. Plant bugs were not a problem in this state, probably because of the extensive treatments for overwintered boll weevils during early season. Other pests observed were aphids and cutworms. Probably the most difficult insect pest problem was the beet armyworm which caused serious problems in August and September.

Insect control costs varied across the state with nonirrigated cotton receiving few applications. Insecticides applied for the boll weevil and Heliothis were effective. However, erratic results were obtained where insecticides were applied for beet armyworm control. This ineffectiveness was attributed to rainfall and lack of coverage.

Louisiana. Early season insect pests were not major problems during 1986, except for thrips. Overwintered boll weevil populations were high based on trap catches, but treatment near overwintering sites and during the pinhead square stage suppressed populations. Other insect pests noted in 1986 were aphids, spider mites, and western flower thrips. Heliothis populations were not typically high, but the population pressure was constant for most of July and August.

Most pests were effectively controlled by recommended insecticides. However, TBW populations in some areas were difficult to control and laboratory tests confirmed resistance to pyrethroids. Moreover, many growers and consultants were not satisfied with the effectiveness of recommended insecticides for control of aphids. However, tests revealed that recommended insecticides were effective, and it was concluded that poor control was a function of high density and not ineffective materials. Cotton matured early in Louisiana due to the drought conditions, early planting, and generally excellent insect control. Usual late season pests such as fall armyworm and beet armyworm caused no problems.

Mississippi. Weather conditions were very dry during the planting and seedling growth period followed by heavy rains during May and early June and then becoming hot and dry during July and August.

The TBW was probably the most severe pest during 1986. There were many reports of failure of recommended insecticides to control TBW populations, and pyrethroid resistance was documented in TBW populations collected from the south delta. Consequently, it has been suggested that pyrethroids be used to control only Heliothis, and that snyergists and chemicals with different modes of action from pyrethroids be used in tank mixtures with the pyrethroids. Other pests noted in 1986 included boll weevils, spider mites, aphids, and western flower thrips.

High temperatures contributed to poor insecticide application conditions. These conditions, along with pyrethroid resistance in the TBW, led to many of the reports of control failures. Other observations included the tendency of growers to apply insecticides for early season insect control on an automatic basis, and the occurrence of damage due to Heliothis feeding and boll weevil oviposition.

New Mexico. The usual difficulties with early spring rainfall and cold periods were encountered, and thrips were pests where early seedling growth was retarded by cool weather. Massive populations of grasshoppers [mainly Melanoplus sanguinipes (F.)] in the southwestern corner of the state threatened all field and vine crops in that area. Twenty-thousand acres of rangeland were sprayed to preempt field crop infestations.

Plant bugs were the most common pest problems from the seedling stage until first bloom. Fields were treated one to three times for these pests in two counties.

Peak egg laying by Heliothis occurred during mid-July and mid-August with some increased oviposition activity occurring from late August through September. Growers in most areas treated one to four times for these pests. Some other pests included armyworms and cotton aphids. The red imported fire ant, Solenopsis invicta Buren, was confirmed for the first time in Hidalgo County.

PBW pheromone surveys showed the usual mid-season increase in adult activity. Counts began to exceed 200 moths per trap in mid-August in Hidalgo, Luna and Dona Ana counties. Adult activity in eastern New Mexico was sporadic. Green boll surveys showed increasing populations of pink bollworm larvae from mid-August through September. In five fields of Dona Ana county larval populations reached 92-96% by late September, but in the majority of fields, populations were considerably lower, usually less than 32% of green bolls infested. Growers in many areas did not treat for PBW. Growers with the heaviest pest pressure treated up to eight times for adults.

In mid-October, boll weevil presence was confirmed in more than 2000 acres in the Juarez Valley, Mexico. Immediately after confirmation, eradication efforts began as part of a cooperative program among Mexican and U.S. officials. The boll weevil has not established in the Juarez area or in New Mexico. The infested area was sprayed with malathion at 7-10 day intervals. All green bolls in the area were being hand-picked. After harvest, the stalks were destroyed and the fields plowed and flooded. Only one adult boll weevil has been captured in a series of pheromone traps run by the New Mexico Department of Agriculture.

North Carolina. This year's cotton crop and insect populations were generally dominated by a severe drought throughout approximately two-thirds of the state. Pest highlights were 1) high thrips populations, 2) an early, severe, but generally brief BW larval population, 3) atypically light damage from European corn borer, Ostrinia nubilalis (Hubner), and 4) scattered high aphid populations on cotton regrowth. Other sporadic pests such as beet and fall armyworms, spider mites and cabbage loopers were of little concern in 1986.

The Boll Weevil Eradication Program in the Carolinas appears to be on course with its scheduled 1987 expansion into Georgia and parts of Alabama and Florida. Although over 600 boll weevils were found in the "eradicated" zone during this initial containment year, no producers had to deal with economic levels of weevils. The down side (thus far, slight compared with the benefits of "eradication") consists of current (stink bugs) and potential (plant bugs)pests filling the insecticide-free void created by the elimination of sprays for the boll weevil.

Warm, dry spring conditions coupled with the drying of wheat created high thrips populations. Although aldicarb- and disulfoton-treated stands were sometimes damaged (presumably nonactivation problems) by thrips, untreated plants showed most evidence of their feeding. Foliar treatments for thrips, atypical for North Carolina, were occasionally required. The efficacy of recommended thrips insecticides was confirmed.

BW pressure in the northern part of the state, though of generally short duration (2-3 weeks), was early and high. A few fields which were inadvertently left out of scouting programs were virtually decimated. Producers who responded early, particularly at the new egg threshold, and with recommended products escaped significant yield loss; those who delayed treatment often faced high numbers of difficult-to-control larvae. Southern producers, conditioned by dependably earlier BW pressure, responded in a timely manner against BW populations which lasted about two weeks. By late July, drought conditions rendered the crop unattractive to insects.

European corn borer populations were very low throughout the state, reversing an upward trend observed for the past six years. Estimates were less than 1% damage based on a 12-county survey of 143 fields. Rank and/or late maturing cotton was more likely to be infested.

The green stink bug, Acrosternum hilare (Say), and the brown stink bug, Euschistus servus Say, were at high levels in fields which received no insecticides. Damage from stink bugs was generally low, but boll damage in one county in the western Piedmont was 15.4%, with approximately one-fourth of the fields running as high as 30%. Cypermethrin or fenvalerate appeared to provide approximately 50 and 75% control of stink bugs for one and two applications, respectively, in the course of managing Heliothis.

Plant bugs again occurred at levels approximately 5 to 20 times lower than in other states where they are an economic problem. Aphids were widespread, particularly late season, but where sooty mold could be found, lint stain generally did not result in grade reductions. A number of fields required spraying for aphids, however. This is another potential pest which could fare better in the absence of insecticide applications directed against the boll weevil. Cotton fleahopper populations occurred at detectable levels and pest status of this insect will need to be evaluated.

Of the approximate 9,000 fields in North Carolina, boll weevil reproduction was detected in two. Of the approximate 6,500 fields in South Carolina north of the Buffer Zone, boll weevil reproduction was detected in less than 15. Boll weevils were captured by late fall in almost all of the approximate 2,500 fields in the Buffer Zone of South Carolina. These captures were expected because of dispersing weevils from Georgia. Diapause prevention treatments were applied in the South Carolina Buffer to prevent economic damage in 1987 and to prevent reinfestation of the Eradication Zone. No infestations of boll weevil approaching economic levels were reported in the Buffer Zone in South Carolina or the Eradication zone in South Carolina and North Carolina during 1986.

Southeastern Alabama cotton growers voted in the fall of 1985 and Georgia growers in the fall of 1986 to expand the current Southeastern Boll Weevil Eradication Program to include southeast Alabama and all of Georgia except the northwest corner. This expansion is expected to occur in July of 1987 or 1988, depending on when the 30% share of federal funding is obtained.

Oklahoma. Unfavorable growing conditions generally delayed planting by about three weeks. However, conditions in September allowed sufficient accumulation of degree day units to produce average yield. Excess rain in October and November reduced yields.

The extremely mild winter allowed high survival of overwintered boll weevils. The average trap capture in three counties in southwest Oklahoma was 56.6 compared with 1.73 in 1985. By August, boll weevils were noticeable in area fields, and in traditional weevil areas, fields were sprayed up to six times. Insecticides used for cotton fleahopper control often include those effective for boll weevil control.

The cool spring slowed plant growth and prolonged the period of susceptibility to thrips. Moreover, the lateness of the overall crop, coupled with a widespread infestation of cotton fleahopper, resulted in a number of fields being treated for fleahoppers.

The majority of the irrigated fields in southwest Oklahoma were sprayed three times for Heliothis. BW moths were first caught in pheromone traps on May 2 and peak moth catches were recorded on June 19, July 25, August 18, and September 17. TBW moths were first caught on May 6. Peak catches were recorded on June 27, July 23, August 26, and September 12. Control difficulties occurred in some fields in the Tipton area, Tillman County during the first week in September. Adverse weather conditions (frequent showers) and an increase in TBW contributed to the reduced effectiveness of pyrethroids.

Twospotted spider mites reached damaging levels in a few fields in early September, but only a few fields were sprayed. Cotton aphids populations remained high throughout the summer resulting in several fields being treated three times to prevent cotton staining.

South Carolina. The severe drought resulted in the lowest average yield per acre in recent years. Because of the drought, plant emergence and seedling development were erratic, thereby complicating pest management decisions. Nevertheless, control of thrips with systemic insecticides appeared to be good. Economic infestations of plant bugs (Lygus spp. and cotton fleahopper) occurred in some fields. Moreover, there were reports of economic infestations of stink bugs.

Fewer insecticide applications than normal were made for control of the F_3 larval generation of Heliothis during mid-July to early-August. However, later Heliothis infestations were more of a problem because the cotton was actively growing and attractive to moths in August and early September following rainy weather. Other pests reported included the beet armyworm and cotton aphid.

Tennessee. The BW and TBW were the major pest problems. Densities of these pests were higher than at any time since the mid-1970's. In July, a major egg laying period occurred with the majority of cotton fields requiring insecticide applications. Overall, damage by boll weevil was slight though farmers in three southern counties did apply insecticides for weevil control. Thrips and green stink bug populations were lower than in 1985. Spider mites, aphids, and whiteflies were present in most fields, but control measures were seldom applied.

Texas. In 1986, 4.4 million acres were planted. This was reduced to 3.9 million acres because of cool, wet planting conditions, excess in-season rains, and hail damage. The majority of acreage reduction occurred in the High Plains and the Rolling Plains. Moreover, yields and quality were reduced in these areas. Texas producers harvested 2.9 million bales.

Insect and mite pests varied greatly across the state. Although thrips populations were not especially high, the plants were already stressed from weather which accentuated the thrips problem. The cotton fleahopper reached damaging levels across the High Plains because of delayed planting and fruiting. BW populations were about average as were aphid infestations.

Far west Texas also had weather conditions that delayed planting. Cotton fleahopper was a major pest throughout the area. The BW and TBW began occurring in mid July and reached damaging levels shortly thereafter. Suppression of Heliothis with pyrethroids synergized with chlordimeform ranged from about 60 to 85%. Boll weevil populations in Glasscock, Reagan and Upton counties required two fall insecticide applications. Boll weevil populations were reintroduced into the El Paso Valley and have become established. They may have originated from Juarez, Mexico. PBW populations attained high levels in several counties. Multiple insecticide treatments were required for PBW in El Paso and Hudspeth counties.

The weather and the boll weevil dominated the situation in the Rolling Plains. Delayed planting helped somewhat, but a large, overwintered boll weevil generation emerging over a prolonged period, caused some damage. Hot, mid-season weather held the weevils in check until late season when populations increased and caused significant damage in certain areas. High numbers of weevils entered overwintering quarters. Cotton fleahopper populations were higher than normal causing a delay in crop development and reduced yield. BW populations were moderate during mid-season and increased in the latter part of the season. Alabama argillacea (Hubner), cotton leafworm, occurred late in the season.

Insect conditions in the central Texas Blacklands and east Texas were variable. Generally, thrips infestations were spotty, depending on the location of wheat acreage. Boll weevil numbers were low. Cotton fleahopper populations ranged from moderate to high. BW reached damaging levels across the central and east Texas area. Most populations were controlled with one to three applications of a pyrethroid or a pyrethroid-chlordimeform mixture.

The Upper Gulf Coast and the Coastal Bend regions experienced low to moderate cotton fleahopper populations. Both areas had moderate to high boll weevil populations as a result of a mild winter. Growers in the Upper Gulf Coast experienced difficulty in controlling TBW with pyrethroids. In nearly all cases resistance was detected before field failures were observed. In most instances the cotton was near maturity and escaped damage from pyrethroid resistant TBW. The short-season production system is still effective. Control failures were observed in areas that have moved away from the short-season system and back to an extended production season.

Growers in the Lower Rio Grande Valley experienced major problems with the boll weevil. High numbers of weevils in the spring caused producers to apply considerably more insecticide than in the previous two years. Lack of stalk destruction the previous fall was thought to be a major reason for the increased weevil numbers. Cotton fleahopper densities were low. Heavy rainfall during mid to late season caused considerable fruit shed resulting in poor mid-plant fruit set. Aphids and spiders required treating 15-20% of the acreage in the Valley.

Estimated Damage to Cotton by Arthropod Pests

Damage to cotton by arthropod pests, consequent losses in yield, and applications of pesticides with consequent cost of control is compiled annually. These data are reported in Table 1 based on information submitted by Extension Specialists as follows: Alabama (R. H. Smith); Arkansas (D. R. Johnson); Arizona (L. Moore); California (V. E. Burton); Florida (R. K. Sprenkel); Georgia (V. R. Lambert); Louisiana (J. S. Tynes); Mississippi (R. B. Head); Missouri (E. Kowalski); New Mexico (C. Sutherland); North Carolina (J. Bacheler); Oklahoma (M. A. Karner); South Carolina (M. Roof); Tennessee (R. E. Caron); Texas (M. McWhorter); and Virginia (J. E. Roberts, Sr.). This information was complied under the auspices of the Cotton Insect Research and Control Conference with support by The Cotton Foundation to help defray expenses associated with development of the data.

The summaries are presented as a summary for all states followed by summary estimates for areas within states. For example, Texas has been subdivided into 14 areas, and in this case a figure (Fig. 1) accompanies these tables to depict the areas. The format for Table 1 and the division of the states into regions for reporting purposes was determined by a "Workshop on assessment of cotton losses to pests," Memphis, Tenn., June 26-27, 1986. The workshop was sponsored by the National Cotton Council specifically to review "the Foundation/Technical Conferences' loss assessment program for cotton diseases, insects and weeds and determination of how it may be improved to better meet the need of users of data on losses to pests."

Additions to Insecticides/Miticides Registered for Cotton Pest Control

Mavrik 2EC (fluvalinate) (Sandoz) received registration for use in cotton during 1986.

Changes in Established State Recommendations for Insecticides and Miticides Used for Cotton Pest Control

Changes for the 1987 crop year are listed in Table 2 by the reporting state.

Insecticides and Miticides Showing Promise in Field Tests

Compounds tested by state and federal researchers during the 1986 crop year which exhibited good field performance are listed in Table 3 by the reporting state.

Research Progress and Accomplishments

Alabama. An outstanding incident of poor Heliothis control was observed during a pyrethroid efficacy demonstration in mid September (Limestone County). A high infestation of primarily TBW was present. Pretreatment counts were 120 larvae per 100 terminals. Larvae ranged from first to fourth instar, but the majority were second or third. Tralomethrin or cypermethrin was applied at one gallon per 19 or 50 acres, respectively, and each was tank-mixed with .33 lb (AI)/acre of methyl parathion. Forty-eight and 96 h percentage control for tralomethrin was 33 and 45%, respectively. Cypermethrin effected 73 and 63% control at respective intervals. Poor application was not a factor, however, no collections were obtained to investigate the possibility of resistance.

Arizona. In the laboratory, Collops vittatus Say, two-lined collops, consumed the highest number of PBW eggs followed by lady beetles, Chrysopa, Geocoris, and Orius. Age-specific developmental times for PBW eggs, larval instars and pupae have been developed and data incorporated in a model for PBW population dynamics. Gossyplure-baited trap catches were highly correlated with PBW flower and boll infestations. So, the traps may be a useful decision-making tool. Cotton-leaf crumple infections vectored by sweet potato whitefly, Bemisia tabaci (Gennadios), and initiated early in the growing season when plants are in the seedling stage dramatically stunted cotton growth and reduced yield. Summer diapause occurs in TBW pupae, apparently as a defensive mechanism to bridge the high summer temperatures in the southwest U.S. PBW oviposition increased in females with two or more spermatophores as compared to females singly mated. The number of eggs per female decreased dramatically when mating was delayed until females were five days or older at first copulation.

Larvae irradiated in diapause were more resistant to effects on subsequent development than irradiated nondiapause larvae. A new gossyplure dispenser reduced insecticide usage for PBW control by 30-50%, and the infestation levels were lower than in fields treated only with insecticide. A nectariless cultivar outyielded a nectaried cultivar in untreated plots but yielded comparably in insecticide or gossyplure treated plots. Resistance to PBW in okra-leaf cotton was evidenced by fewer larvae penetrating the bolls and not by

increased egg mortality. The most resistant of 35 nectariless cottons that also carried antibiosis had 37% as much PBW seed damage and yielded 2% more lint than a commercial cultivar. An advanced nectariless, okra-leaf isoline had 46% as much seed damage and yielded 95% as much lint as its nectaried, normal-leaf counterpart.

Ethephon applied in early September at 1 or 2 lb/acre effectively terminated cotton fruiting, flowering, and reduced overwintering PBW populations. Two applications at weekly intervals were more effective than a single application. Topical application of pyrethroids to field-collected PBW moths confirmed the 12 to 20-fold resistance that was reported in 1984 in the Imperial Valley of southern California. No resistance to azinphosmethyl occurred. Laboratory tests showed that sublethal doses of Bacillus thuringiensis (Bt) showed a synergistic effect against BW and TBW larvae when added to a nuclear polyhedrosis virus (NPV) of H. armigera (Hubner); however, at higher rates, these two materials were antagonistic. Also, low rates of Bt exhibited synergistic effects against TBW when combined with methyl parathion at low rates, indicating that low rates of both in combination could be used to give control comparable to or better than either at higher rates.

Electrophoretic analysis of boll weevils from two areas of Brazil demonstrated that these weevils were genetically similar to Texas weevils, but not closely related to each other. (USDA - Phoenix)

Releases of a parasite of Lygus nymphs, Peristenus stygicus Foerster, made in London rocket during February-March at Tucson yielded parasitism up to 28.7% and indicated completion of two generations before the host plants died. Two braconid parasites of Lygus nymphs from Kenya, Leiophron sp. and Peristenus nigricarpus Foerster, are being reared on the tarnished plant bug.

Adults of a Lygus egg parasite, Anaphes ovijentatus Haliday, labeled with rubidium dispersed at least 30 m in 24-36 h, but few were found after 84 h. Individuals of a laboratory colony of L. hesperus began to enter diapause when reared under a 14-h photophase; a 50% diapause response estimated by probit analysis was found to occur at 11.9-h photophase.

A defined diet for Geocoris punctipes (Say) sustained development from the 3rd to 5th instars, but no adults were produced; however, early 5th instars were reared to adulthood and reproduced. Thus far 21 successive generations of G. punctipes have been reared on the Cohen meat-based diet. Rutin, which adversely affects Heliothis spp. when fed upon, did not affect G. punctipes when fed in the meat diet. (USDA - Tucson)

Arkansas. Significant progress was made in evaluating the effect of thrips on cotton maturity, earliness, and yield. An effort is underway to determine the effect of a dynamic treatment threshold for plant bug control. The research keys on monitoring plant bug damage using a recently developed square slicer to determine the cause of square shed. Area wide control of boll weevil has been the target of programs to trap boll weevils on field borders using pheromone. To date the effort has achieved success in fields tested. Area control efforts directed at Heliothis include use of reduced insecticide rates. The control strategy is directed towards populations of eggs and larvae less than 1/4-in. long. The program has been successful in identifying insecticides and rates that may be used in community bollworm control. (Univ. of Arkansas)

California. Research was focused primarily on miticide resistance and evaluation of candidate pesticides for spider mite and Lygus control. Other research involved plant resistance to Lygus, pest and beneficial insect numbers in relation to soil tilth, and beet armyworm control. Spider mite resistance was found to be highly variable from year to year and field to field, and it apparently relates to the particular crop source of the invading population. Resistant populations can usually be managed with dicofol or propargite provided the beneficial fauna has been preserved to serve as a management aid. In areas of resistance, elimination of the beneficial fauna with broad spectrum insecticides will frequently make further acaracidal control difficult or impossible. Candidate acaracides, avermectin, thuringiensin, bisclofentezin, and hexythiazox provided effective spider mite control in small plot field experiments. Oxythioquinox provided effective control for about three weeks under severe spider mite pressure. An experimental compound RH 70-23 also provided excellent spider mite control under limited test conditions. The effect of these compounds on nontarget arthropods was also assayed.

Thuringiensin was evaluated for control of plant bugs. This compound provided excellent control under moderate infestation pressure but was somewhat less effective against a heavy invasion of adult Lygus.

Applications of biphenthrin or methomidophos + chlorpyrifos for control of beet armyworm were very effective. Control of small worms was excellent and feeding by large worms was greatly suppressed. (University of California - Davis)

Florida. The preparation of an artificial oviposition substrate (AOS) from agarose and host hemolymph for oviposition by a parasitic wasp, Microplitis croceipes (Cresson), was described. Natural hosts for this endoparasitoid are the larvae of Heliothis spp. Infusion of hemolymph from the BW into a drop of solidified agar induced females of M. croceipes to oviposit into the material. The factor(s) that stimulated oviposition was moderately heat sensitive, dialyzable, and was unaffected by treatment with protease or pancreatic trypsin or hexane extraction. Use of the AOS will facilitate in vitro efforts to rear M. croceipes because dissection of host larvae is eliminated and large numbers of eggs can be collected easily.

The flight response of M. croceipes to host odors has been analyzed in wind tunnels, and sources of the odors that mediate the host-locating behavior of the M. croceipes females have been identified. Research to identify the semiochemicals that mediate this behavior is in progress. Elucidation of the semiochemicals and associated behavior involved in parasite host location should allow the development of methods to enhance the effectiveness of parasites in biological control programs.

The pheromone blend emitted by calling TBW females has been collected and analyzed and found to consist of a specific ratio of six aldehydes. A synthetic blend of these six aldehydes, formulated on rubber septa to release the same ratio of compounds released by calling females, is more attractive to TBW males in wind tunnels than any other lure. In a field test the six aldehyde blend was superior to virelure and a commercial blend as a trap bait.

The pheromone produced by male TBW in courtship has been identified. This knowledge may enable development of new ways to interfere with mating.

The terminal step in the biosynthesis of the TBW pheromone has been elucidated. Primary alcohols, which are precursors to the pheromonal aldehydes are produced in the pheromone gland. However, these alcohols are not released by the female, but are converted to aldehydes by an enzyme in the gland cuticle. Thus the less stable aldehydes are produced and released as needed during calling by the female. This knowledge may enable development of methods to interfere with pheromone biosynthesis. (USDA - Gainesville).

Georgia. Evaluation of the efficacy of applying insecticides through overhead irrigation systems for control of cotton insect pests continues. Control of Heliothis spp. was considered excellent in all trials. The boll weevil, however, was not controlled as well as where conventional ground equipment was used. Where application intervals were decreased, boll weevil control could be maintained at acceptable levels.

Dose-response analysis using selected insecticides on the BW, TBW, and the fall and beet armyworm was continued. No changes were noted in susceptibility to the pyrethroid materials for any of these species compared with data obtained from previous years. There was an indication of decreased susceptibility to methomyl in the BW compared with previous data.

No significant differences in cotton yields were obtained from the use of early season applications of

insecticide where applied for "yield enhancement." Treatments included pyrethroids, carbamates, organophosphates and formamadines. The test area was oversprayed with a pyrethroid on the same day as the test treatments in an attempt to limit the influence of insect pest populations on results. Insect populations during the course of the study were negligible. (University of Georgia)

Louisiana. Resistance monitoring using the topical application technique for larvae and insecticide coated vials for adults revealed that the frequency of pyrethroid resistant TBW increased in some areas of Louisiana in 1986 to the extent that control problems were evident in fields with high populations. Increases in larval LD_{50}'s for cypermethrin and fenvalerate usually were only two to three fold higher than normally expected. However larval LD_{90}'s for these pyrethroids were often considerably higher (3h to 9 fold) than expected. Larval responses to other pyrethroids varied considerably with the least change in response occurring with cyhalothrin. Responses of adult male moths were similar to those of larvae indicating that the adult monitoring technique can be used to effectively, easily, and quickly monitor pyrethroid resistance development in Heliothis.

Mixing acephate, chlordimeform, chlorpyrifos, profenofos, sulprofos or thiodicarb with pyrethroids generally gave better control of Heliothis, primarily TBW, than pyrethroids alone in replicated fields tests. These data support the resistance monitoring results showing higher frequencies of pyrethroid resistant TBW.

Field experiments were used to evaluate the efficacy of aldicarb on thrips populations when applied to four soil types. Aldicarb controlled thrips more effectively and longer on light soils than on heavy clay. Yield increases were obtained by using aldicarb on the light soils but not on the heavy clay.

Efficacy testing of new insecticides for use in cotton pest management included pyrethroids: (permethrin, fenvalerate, fluvalinate, tralomethrin, cypermethrin, flucythrinate, biphenthrin, cyhalothrin, cyfluthrin), organophosphates (sulprofos, profenofos), and a carbamate (thiodicarb). Performance by rate and timing was evaluated for many secondary and major pests. Small plot and large experimental use permit tests were conducted, keying on development of integrated pest management strategies using infurrow systemic insecticides, fungicides, chlordimeform, and the above insecticides. Management tests demonstrated that increased early season pesticide inputs (in-furrow systemics, fungicides, and early season foliar sprays) could be used in many of the high production regions, with resulting yields that maintain good treatment cost to yield ratios. Length of the growing season was stabilized to a normal 140 to 150 day season through increased insect protection, allowing less opportunity for development of late season pests. Cooperative research revealed that disease control, weed control, nitrogen utilization, and water use requirements need further evaluation. Spider mite efficacy with biphenthrin was demonstrated at 0.04, 0.05, and 0.06 lb (AI)/acre and 80% suppression of mites was demonstrated with cyhalothrin at 0.03 lb (AI)/acre. The pyrethroids demonstrated weak activity on aphids. Biphenthrin suppressed low populations on seedling cotton but did not provide adequate control of mid-season high populations.

Evaluations of insect resistant cultivars possessing traits of red leaf color and frego bract showed that boll weevil management could be accomplished with decreased insecticide usage. Establishment of a top crop by early planting was eliminated. Three years of on-farm trials showed that interplanting frego cotton (a short season and early fruiting strain) provided the necessary time differential to attract large numbers of overwintered weevils.

The in vitro hydrolysis of trans-permethrin, cis-permethrin and fenvalerate was monitored in eggs, larval instars, pupae and adults of the TBW. In general, the rate of hydrolysis (picomole per minute per individual) increased from the egg to the last larval instar, and then decreased in pupae and adults. However, hydrolysis on a picomole per minute per milligram protein basis was maximal during the first and second larval instars. For all stages, trans-permethrin was hydrolyzed much more rapidly (ca. 20-fold) than either cis-permethrin or fenvalerate. Trans-permethrin was also much less toxic (ca. 5-fold) to third and last instar larvae of TBW than either cis-permethrin or fenvalerate. Thus, the relative ease of hydrolysis appears to correlate with decreased toxicity for the three pyrethroids studied.

Field collected (F_1) TBW larvae from the Imperial Valley of California were ca. 7-fold less susceptible to flucythrinate than larvae from a laboratory strain. Continued selection in the laboratory with flucythrinate of this Imperial Valley (IV) strain resulted in LD_{50} values that were ca. 68, 53, 16, 23, and 2-fold higher than the susceptible laboratory strain for flucythrinate, fenvalerate, DDT, carbaryl and ethyl parathion, respectively. This IV strain was also found to be ca. 12, 5, and 3-fold less susceptible to trans-permethrin, cis-permethrin and fenvalerate, respectively, compared with another laboratory strain (LSU lab). Although piperonyl butoxide failed to synergize trans-permethrin in the IV strain, profenofos (a potent inhibitor of trans-permthrin hydrolysis) provided a high level of synergism (ca. 47-fold) such that the profenofos - trans-permethrin mixture was nearly as toxic to the IV strain as it was to the LSU lab strain. The IV strain hydrolyzed all three pyrethroids two to three times faster than the LSU lab strain. Isoelectric focusing indicated both qualitative and quantitative differences between the IV and LSU lab strains. As in the in vitro assays, trans-permethrin was hydrolyzed at a higher rate in the IV strain compared with the LSU lab strain, and possessed an additional peak of enzyme activity. Thus, the pyrethroid resistant IV strain of TBW is less susceptible to the pyrethroids, in part, due to an additional enzyme capable of hydrolyzing pyrethroids and an overall increase in pyrethroid hydrolytic capatibility. (Louisiana State University)

Mississippi. The Cotton Insect Management (CIM) model has been restructured for use on personal computers. Research and extension entomologists are currently exploring potential uses of the model.

Pyrethroid insecticide resistance has been detected in populations of TBW in Mississippi. Research corroborates the reports of Texas scientists that TBW in Texas are resistant to pyrethroids. Laboratory studies indicate that mortality of adults in an insecticide-coated vial assay technique developed in Texas closely correlates with the mortality of third-instar larvae under field treatment conditions.

Studies with the fall armyworm as a pest of cotton indicate that moths prefer to oviposit on the underside of lower leaves, that survival of early instar larvae is low on cotton, and that many insecticides will kill fall armyworm larvae if they contact adequate dosages. Lack of control in field situations appears to be associated with the tendency of larvae to feed at lower positions on the plant.

In a season-long study of clouded plant bug, Neurocolpus nubilus (Say), populations were detected and studied on paper mulberry, dewberry, sumac, buttonbush, cotton, and cockleburr. Buttonbush appeared to be preferred. The ovipositional site on cotton was the base of young stems.

Continuing research with insecticide resistance management, indicates that combinations of pyrethroids with chlordimeform aids in control of resistant TBW.

1985-86 PBW overwintering studies at Stoneville, MS, indicate that survival of this pest in the Mississippi Delta was possible in cotton bolls located on the soil surface or suspended above the surface.

First year aphid threshold studies indicate that significant yield loss was correlated to age of aphid infestation. If future research verifies these data, thresholds may need to be lowered and/or sampling techniques evaluated to insure maximum economic yield.

Radioprotectants incorporated in the post-emergence diet of boll weevils for five days prior to irradiation resulted in significant differences in post-irradiation survivorship. Kanamycin sulfate-Chloramphenicol-Penicillin V at 0.04% plus 0.5% Ascorbate incorporated in the diet provided the greatest longevity of post-

irradiated weevils of compounds and combinations tested.

Western flower thrips damage to cotton blooms was evaluated by scanning electron microscope. Pollination did not seem to be inhibited. Other damage such as loss of fruit or seed production is undetermined. Evaluation of seven insecticidal treatments of heavily infested cotton resulted in no significant differences of thrips in blooms when compared to the untreated check at 24 h post spray. Difficulty in controlling this pest with insecticides may relate to behavior of adults attracted to blooms, reproductive capacity, mobility of adults, the low action of systemic insecticides in peripheral cells of plant tissue, and other related factors.

Small plot insecticide evaluations for control of Heliothis larvae indicated that pyrethroids at standard rates and pyrethroids at lower rates plus chlordimeform at 0.125 lb (AI)/acre generally produced higher yields than non-pyrethroids in the same test. Aphid populations tended to increase in most pyrethroid treated plots in comparison with plots treated with pyrethroids in combination with chlordimeform (at 0.125 lb (AI)/acre) or chlorpyrifos or profenofos at various rates.

Efficacy evaluations for aphid control conducted indicate a broad spectrum of compounds that effectively control aphids on cotton.

Small plot insecticide efficacy trials targeting tarnished plant bug nymphs in cotton bordered by mustard plants indicated that pyrethroids were harsh on beneficials as compared with chlorpyrifos, chlordimeform, and several systemic insecticides at recommended rates. Esfenvalerate at 0.03 lb (AI)/acre was less effective on nymphal Lygus than other entries in the test.

Large plot (1/2 acre) insecticide trials using B.t. at 3 rates with and without chlordimeform indicated better control of Heliothis larvae with chlordimeform at 0.125 lb (AI)/acre than without. However, control as tested was inadequate with all treatments. (Mississippi State University)

The Crop Simulation Research Unit has developed code and completed the first stage of controlled environment experiments to characterize and simulate developmental rates (as functions of temperature) in BW, TBW, and tarnished plant bug. Feral insects collectd in north Mississippi were used. The tarnished plant bug experiments also characterized longevity and fecundity. These and other data on the boll weevil have been summarized and incorporated into the insect simulation model BUGGOS which is designed to simulate development of multiple species populations and their interactions with each other and the host plant.

Sterile boll weevils that were mass-reared at Mississippi State were about 80% as competitive as Arizona native weevils in small plot tests conducted near Tucson, Arizona. Longevity of the sterile weevils was greater than expected under the hot Arizona climate. More than 50% of a sample of sterile weevils held in cages on the plants were still alive at the end of the 6-day test. The fields were irrigated during the course of the test, and this cold have contributed to the high levels of longevity and competitiveness.

The addition of beta-carotene to the larval diet on which sterile weevils were reared improved their visual sensitivity, but field competitiveness was not increased. Visual sensitivity of sterile weevils reared on larval diet without beta-carotene increased after 24 hours of feeding on cotton squares, and between 48 and 72 hours the sensitivity was not significantly different from that of the controls. As pheromone production increased so did visual sensitivity, and by the time sterile weevils were producing enough pheromone to attract a mate and vision was much improved over that measured at the time of release. This could explain the lack of significant differences between the treatments, as could the hypothesis that vision is not an important factor in competitiveness.

The inheritance of lavender-eye in the boll weevil was determined to be sex-linked and recessive. Tests were conducted to determine whether crossing-over would occur between lavender-eye and the dark-scale, also a sex-linked recessive. The frequency of recombination of these genes was determined to be 25.3%. These genetic markers along with several others maintained by the Boll Weevil Research Unit could play an important role in studies of the genetics of the boll weevil, particularly the development of a genetic sexing system.

The locomotor activity of diflubenzuron-fed, irradiated boll weevils was about one-half that of the controls. A pre-irradiation diet of 2.5% sucrose increased activity when squares were fed after irradiation.

Computerized multi-channeled flight mills are being used to assess the potential of the boll weevil for long range dispersal. The flight propensity of fat (probably destined to enter diapause), intermediate, and lean weevils is being assessed. Flight propensity was proportional to ordinal measurements of fat quantity. Fewer than 50% of the lean weevils flew compared with 50-80% of the intermediate weevils and 60-90% of the fat weevils. Lean weevils are usually captured on traps away from cottonfields. Weevils in the three categories above have not yet been tested on the flight mill.

Standardized laboratory procedures were developed for evaluating controlled-release pheromone dispensers. Even moderate amounts of air movement were found to significantly increase the rate of release of grandlure, the aggregation/sex pheromone of the boll weevil. Regression models were derived which describe the effects of temperature and air movement on the release of grandlure. These models can be used to predict the performance of a lure formulation under a given set of environmental conditions.

The total amount of grandlure produced by native males and the ratio of the four components change over the course of the season. Mid-season males produce the highest amounts of pheromone and late season males produce the least. A field test was begun to determine if altering the ratios of the components will affect the response of native weevils over the course of the growing season. Eight different ratios, including the standard 30-40-15-15 and the differing ratios produced over the course of the season, were used in traps placed in three areas that were at least 30 miles apart in August 1986. Over 16,000 weevils were captured between August and November 1986. Mixtures low on the aldehyde components captured about as many weevils as the standard ratio. The test will be continued over the entire course of the 1987 season.

In 1985, six 1-acre cotton plots were planted and infested with feral weevils. Three fields were sprayed weekly for four weeks. The three remaining fields were treated and then the stalks were destroyed after the last application of insecticide in the first three fields. Pheromone-baited traps were placed in all six fields in 1986, and none of the fields was replanted. The three fields that received the early insecticide applications had 7% of their total emergence occur after ovipositional sized squares had appeared compared with 15% in the fields that were destroyed to prevent entry into diapause after September 18. In 1986, six additional plots were planted. Three of the fields were treated starting in mid-July, a full month earlier than the previous year. These six fields will not be planted in 1987, but emergence patterns will be determined.

LY 121342, LY 135926, CGA 112913, and SIR 8514 were tested by dipping and feeding (3 days). All were 100% effective using one or both methods at one or more concentrations. In dipping tests LY 135926 was the most effective; weevils were sterilized at concentrations of 0.032-1.0 percent for two weeks. In feeding tests CGA 112913 was the most effective. Weevils were sterilized with a 2% treatment for two weeks afterward. Mortality of weevils treated with LY 135926 averaged 20.7% after 14 days compared with 4.5% mortality with CGA 112913. As a result of lower mortality with CGA 112913, the weevils were healthier and more competitive. This was verified by increased flight in tests designed to measure weevil vigor.

Compound eyes of boll weevils reared on the standard

Gast larval diet were significantly less sensitive to visible light (480 mm - 600 mm) than weevils reared on their host plant, cotton, or the same standard larval diet supplemented with the carotenoids, beta-carotene, and retinyl palmitate. The addition of beta-carotene to the larval diet increased the sensitivity of the compound eye to all wavelengths tested to a level not significantly different from weevils reared on their natural host. Preliminary results from another experiment indicated that increasing the dosage of beta-carotene in the larval diet leads to increased photosensitivity up to a level equal to that of the field weevil. However, after reaching that point, further addition of the carotenoid did not result in a further increase in sensitivity of responsiveness. ERG's elicited by a white light stimulus, which approximated illuminances during peak field behavioral activity, were significantly larger for weevils reared on the standard larval diet + beta-carotene than those reared on the unsupplemented diet. However, ERG's were obtained from weevils fed the unsupplemented diet which indicated that these insects did perceive light in the field as shown in behavioral tests.

Preliminary results of electrophysiological experiments on developing boll weevils show that responsiveness of olfactory receptor cells sensitive to the aggregation pheromone and plant volatiles increases at least through day 4 of adulthood. These results coincide with sexual maturation and mating of adult weevils. Thus mating behavior may be governed by peripheral sensitivity to chemical messengers rather than central processes.

Both male and female boll weevils were attracted to grandlure in the dark. However, when the pheromone was present with light of several wavelengths, neither sex was significantly responsive to the pheromone over the solvent control except for females which were attracted to the pheromone in combination with green (dominant lambda = 510 nm). Field trapping tests with a laboratory reared native strain revealed that while females were more responsive to the pheromone, similar percentages of each sex were more responsive to the pheromone, similar percentages of each sex were captured on three traps representing diverse wavelengths, i.e., red, green, and blue. Thus, it appeared that both sexes respond similarly to pheromone and trap color in flight, but ambulatory responses of the sexes could possibly differ. Since males producing pheromone in the field are veiled by bracts surrounding the square, only females might orient to the green + pheromone combination.

Preliminary results of single cell recordings revealed cells which were reliably activated by pheromone components in both male and female weevils. Only one cell out of nine cells which responded to odors tested was activated by a known host odor. A large number of cells were not activated by any odor tested.

Female boll weevils have a meroistic type of ovarian development where each developing follicle connects to the trophocytes by way of a nutritive cord. This ovarian development component subtype is known as teleotrophic. The oocytes are surrounded by a layer of follicular epithelial cells. Each follicle contains an enlarged nucleus or germinal vesicle and follicles are connected to one another by interfollicular tissue. A physiological age grading system is also described where three nulliparous (N1, N2, and N3) and four parous stages (P1, P2, P3, and P4) are characterized. Nulliparous stages are separated primarily by the degree of follicle differentiation and vitellogenesis. Parous stages can be distinguished by the quantity and appearance of follicular relic deposition in the ovariole base and the presence of absence of degenerating follicular and germarial tissues. Parous stages P1, P2, and P3 correlate positively with the number of eggs oviposited. Higher numbers of ovipositions are associated with the P3 individuals.

Research pertaining to the chemical analyses of both natural and artificial diets has been completed. Water is the major component in both kinds of diet and found in quantities > 82% wet weight while crude protein plus nitrogen-free extracts account for > 85% of the dry matter. Crude fiber is significantly higher (13.3%) in the cotton square compared to the artificial diet (ca. 2.0%). Similarly, concentrations of ether extractable compounds are significantly higher in the squares (8.8%) than the non flash-sterile diet (4.2%). Also, water soluble carbohydrates, glucose, and starch are higher in the squares-9.2%, 0.1%, and 5.8%, respectively when compared to those found in the artificial diet-0.75%, 0.01%, and 0.9%, respectively. No differences were observed in percent ash but potassium, sodium, and iron are found in higher concentrations in the artificial diet while zinc, manganese, and chlorine are higher in the natural diet. Lower percentages of moisture and ether extractable compounds as well as lower concentrations (mg/g) of Ca, Mg, Fe, Zn, Mn, and Na were measured in the artificial diet following flash-sterilization. This information could be useful for gaining a better understanding of how specific nutrients affect the biology and behavior of the weevil.

Weevils reared on the currently used Pharmamedia® diet were shown to have a significant reduction in their photoreception via electroretinograms when compared to native weevils or those fed natural diet or diet supplemented with beta-carotene. Work has been completed and a manuscript is presently being prepared which accounts for the incorporation of beta-carotene into the diet and its effect upon the biology and behavior of the weevil. No significant differences ($P<0.05$) were found in respect to adult body weight, percent survival to the adult stage, and walking/flying capabilities for those fed control diet without beta-carotene or diet supplemented with beta-carotene at the rate of 160 micrograms/g diet. In a second test where weevils were fed as larvae on beta-carotene concentrations of 0, 1.6, 16, 160, or 1600 microgram/g of diet, there was no significant difference ($P<0.05$) in pupal or adult dry weights (mg), percent survival to the adult stage, walking/flying capabilities, percent copulation or percent insemination. However, a significantly higher number of weevils exhibited a positive orientation response to a light source when they were fed the 16 microgram/g, or higher concentration, of beta-carotene in the diet.

It was demonstrated that the response time in the "Photo Response" test could be reduced from 1 h to 15 min without reducing the precision of the test. This assessment was used to profile each group of newly emerged boll weevils produced. This assessment was also used extensively in evaluating the response of boll weevils to various levels of beta-carotene enrichment of the synthetic diet.

It was also demonstrated that response time in the "mobility" assessment test could be standardized at 1 h in the large test chambers. Further, no precision was lost when the test was run in similar containers of ca. 50% the diameter of the larger chambers thus reducing the physical space requirements for this procedure. This assessment was used to profile each group of newly emerged boll weevil produced.

On-going radioprotectant studies have produced a significantly longer lived sterile weevil. Studies are being designed to evaluate candidate chemicals (currently yielding an in-lab. LT 50 of 10 or more days post irradiation) in respect to pheromone production and mating ability for potential use in producing a weevil suitable for a 7 day or longer field release cycle in an irradication program.

A cold temperature rearing regimen was conducted to evaluate potential cost reduction procedures for the maintenance colony during low production periods. Results indicated that the procedure was advantageous with significant labor and material savings, particularly when production was limited to colony maintenance only with specific boll weevil implant equipments.

A program was initiated to develop and adapt Heliothis propagation to an automated tray preparation process similar to principals employed with the current boll weevil rearing program. Preliminary studies conducted in 1984-85 led to the development of a 6 in x 12 in tray fabricated to form 32 cells with 7 ml diet capacity per cell. A die dispensing head with a specialized pumping system was designed, tested, and modified to dispense diet into each cell of the rearing tray. The system delivers a uniform quantity of diet and is designed to employ only two pumps. The dispensing system was designed for durability and sanitation. Investigations were conducted to evaluate the

feasibility of implanting eggs on trays in liquid suspension rather than as dry eggs or larvae; investigators preferred eggs suspended in solution due to operational advantages. Investigations led to a satisfactory liquid egg implant process therefore, a specialized dispenser was fabricated and tested to deliver one drop of egg mixture to each cell in the tray. Investigators elected to utilize an antibiotic cob cover over the diet surface for microbial protection, moisture absorption, and provide a dry resting site for eggs dispensed in the cells. Two cob dispensers have been fabricated and tested with good results. An effective mylar lidding material that retains Heliothis larvae in the tray cells and the identification of a poly-vinyl-chloride film (PVC) for tray construction rather than virgin plastic as PVC is clear and enhances monitoring the development of larvae in cells. (USDA - Mississippi State)

A field experiment compared the effectiveness of a mixture of microbial insecticides (NPV and B.t.) with and without a feeding stimulant, to fenvalerate in the control of Heliothis spp. in late-planted cotton. Yields of seed cotton were increased by 10.7, 22.5, and 28.8% in plots treated four times with virus + B.t., virus + B.t. + COAX®, and fenvalerate, respectively, compared to the untreated control. Although the addition of the feeding adjuvant increased the effectiveness of the microbials, results were not as positive as in previous studies at a different location. Part of the effect might have been masked by parasites and the use of methyl parathion for boll weevil control.

A greenhouse trial demonstrated that TBW could be internally marked with an oil-soluble dye by feeding on treated Geranium dissectum. Although 80% of the adults from the greenhouse plants were marked, only ca. 24% of those emerging from a treated natural field were found to contain dye. Development of a reliable marking technique would aid in the evaluation of using insect viruses for control of Heliothis spp. on early season alternate host plants.

Thiodicarb, chlordimeform, cypermethrin, cypermethrin + chlordimeform or thiodicarb + chlordimeform were applied at weekly intervals during the first four weeks of squaring. Aldicarb (0.56 kg (AI)/ha) was applied in-furrow at planting to all treatments except the check. Geocoris punctipes was the most numerous predator found. Neither thiodicarb nor chlordimeform significantly reduced punctipes populations below levels found in the check. The combination of thiodicarb + chlordimeform did not significantly reduce G. punctipes populations. The highest reduction of all predatory arthropods was found in the cypermethrin treatments. Better control of low to moderate populations of the tarnished plant bug and cotton fleahopper was obtained with cypermethrin and cypermethrin + chlordimeform. Cotton aphids were significantly higher in the check treatment without aldicarb. Heliothis spp. populations were higher than during previous years although square and boll damage never exceeded 3% in any week. All insecticide treatments had higher yields than the check although differences were not significant. The impact of scheduled early-season applications of insecticides on cotton arthropods and yield was studied. Ten insecticides representing four classes (organophosphates, carbamates, pyrethroids, and formamidines) were tested in a large field plot study in Sunflower County, Mississippi. Dimethoate, dimethoate + chlordimeform, chlordimeform, acephate, dicrotophos, chlorpyrifos, cypermethrin, esfenvalerate, biphenthrin, and fluvalinate were applied at rates of 0.22, 0.22 + 0.14, 0.14, 0.21, 0.22, 0.22, 0.045, 0.034, 0.028, and 0.056 kg AI/ha, respectively. These treatments were applied weekly during the first 4 weeks of squaring to cotton that received aldicarb (0.56 kg (AI)/ha) at planting for thrips control, and to non-aldicarb treated cotton. Populations of most of the major beneficial arthropods were reduced to levels below that found in the check. Tarnished plant bug populations were moderate with the adult and nymphal populations exceeding 14,000/ha in May and 12,000/ha in June in the check. Populations of the cotton fleahopper exceeded 14,000/ha in June in the check treatment. All insecticide treatments reduced populations of both plant bug species below that found in the check. Populations of the cotton aphid were higher in most treatments without aldicarb. Pyrethroid treatments without aldicarb had higher mean numbers of aphids than other treatments. Aphids in the cypermethrin and biphenthrin treatments (without aldicarb) were significantly higher than found in other treatments. None of the insecticide treatments had significantly higher yield than the check, although the majority of treatments with aldicarb (because of better control of secondary pest) yielded more seed cotton than the same treatments without aldicarb.

Commercial formulations of pyrethroids, organophosphates, and carbamates were applied directly to M. croceipes adults at field rates. At high and low rates fenvalerate failed to kill the wasps, although some knockdown was seen at the highest recommended field rate. The lowest recommended field rate of acephate caused 100% mortality in M. croceipes. There was no mortality among wasps sprayed with the lowest recommended field rate of thiodicarb.

A simulation model for decision making in management of Heliothis spp. on cotton was developed. The model (DEMHELIC) uses scouting data on insect densities and on the state of the crop, and it recommends the control to use by comparing economic returns of the available options. The model has structures for cotton crop growth, Heliothis feeding, impact of beneficial insects on Heliothis feeding and survival, insecticidal mortality of Heliothis and beneficials, and economics of pest control. Maturity and temperature drive crop growth. Age of larvae, relative abundance of fruiting forms, and temperature drive feeding rate of Heliothis, and temperature drives Heliothis development. Best, worst, and intermediate weather years are used to generate a range of predictions for impact of Heliothis on yield. A simple search equation is used to model attack by natural enemies. Decisions are for single fields or small sets of fields and must be updated at least weekly.

Microplitis croceipes courtship and mating were studied in the laboratory. Effects of female mating status and age were noted. The reproductive anatomy of male and female M. croceipes was described and possible source of the sex pheromone was determined, and active extracts were prepared. Males exhibited positive anemotaxis (wind borne odor mediated flight) to parasitoid females and extracts in a wind tunnel.

Field releases of C. kazak from New Zealand, Palexorista laxa from Kenya, Hyposoter didymator from France, and M. demolitor from Australia were made in cotton that was artifically infested with TBW. Low numbers of parasitoids were recovered. These same parasitoids were shipped to cooperators in North Carolina, Tennessee, and Texas.

The flight behavior of M. croceipes and Campoletis sonorensis (Cameron) was studied in a wind tunnel olfactometer. Females, but not males, of both species exhibited odor directed, oriented flights to fresh cotton leaves, although flight frequency was related to variation in wind velocity, differential cotton volatile emission with changes in wind velocity, or both. Flight frequency at constant wind velocity was affected by illumination. Campoletis sonorensis flight frequency increased under relatively strong light intensity and decreased under relatively low light intensity. The converse was shown for M. croceipes. Microplitis croceipes was attracted to the wind borne odor of TBW frass and larvae, whereas C. sonorensis was not. Possible interaction of the wind borne odors from the habitat and host is suggested for parasitoids.

Several growth regulating compounds (inhibitors of chitin synthesis) were evaluated in laboratory and field tests for their effect on nymphs of the tarnished plant bug, big-eyed bugs, and minute pirate bugs. UC-84572 was the most effective compound tested for nymphs of the tarnished plant bug in the laboratory and field tests. It also produced high mortalities in the laboratory among big-eyed bug and minute pirate bug nymphs, but did not significantly affect egg production or percent hatch when male and female boll weevils were exposed to several concentrations of the chemical.

Several preliminary projects were conducted in preparation for a large-scale, 3-year pilot test aimed at (1) examining the feasibility of calibrating sex pheromone traps for monitoring Heliothis spp. populations, and (2) measuring Heliothis spp. dispersal rates for use in planning future wide area management tests. The pilot test will be carried out by ARS laboratories at Stoneville, MS; College Station, TX; and Tifton, GA.

In addition to identifying appropriate field sites in the Mississippi Delta, TBW and BW pheromone traps were monitored to assess trap to trap variability and test the proposed experimental design. Results suggest that, while trap location and size affect capture numbers, variance remains consistent among traps over the season. Laboratory and field cage experiments were conducted to develop techniques for labelling Heliothis spp. with trace elements for mark-release-recapture studies. Using atomic absorption spectrophotometry, rubidium and cesium, singly and in combination, were reliably detected in eggs from adults reared on treated diet (100% and 90%, respectively, exceeded the range of unlabelled controls). In field cage studies, rubidium was successfully used to mark eggs from adults reared on treated corn and pigeon pea.

Foliar or soil treatment in plots of G. dissectum using salts of rubidium or strontium effectively labelled Heliothis larvae and allowed detection of marks in moths. Substantially lower application rates were required with rubidium chloride than with strontium chloride and with rubidium chloride applied as a foliar rather than as a soil treatment.

During 1984-86, 60 different non-agricultural sites and 10 adjacent cotton fields in the delta area of Mississippi were sampled weekly for tarnished plant bug. Each non-cotton site was selected to contain at least one species of Erigeron, a suspected important alternate host plant of the tarnished plant bug. During the bud/bloom period in cotton (June-July), tarnished plant bug populations were high in cotton for a particular year if few Erigeron plants wee concurrently blooming. TPB populations in cotton were low for a particular year if blooming Erigeron plants were abundant during June-July. Previous lab experiments have demonstrated a weak preference of the tarnished plant bug for cotton, relative to most other food plants. This field data supports the hypothesis that TPB populations in cotton (and their resultant damage) are a function of the availability of alternate host plants and suggests a control strategy of cultural manipulation.

As part of a pilot test, "Suppression of Heliothis spp. Through Early-Season Management," the species of wild host plants of Heliothis present in a 4,144 ha core area, along with their distribution, density and total surface area were determined. Populations of Heliothis spp. larvae on the hosts were also sampled during April and May. The most abundant hosts were Geranium dissectum L. and G. carolinianum L. Geranium spp. averaged 6.2 plants/m^2 in ditch margins and 2.8 plants/m^2 in field margins. Larval populations peaked on 13 May, averaging 190 larvae/ha of wild host plants. Of the 4,144 ha, only 2.2% was rated as suitable habitat for Geranium spp. The study area was divided into 16 sections. Two pheromone traps, one baited with zealure and the other with virelure, were operated in each section from 7 March through 16 October. Moth catches will be correlated with the local abundance of wild host plants and Heliothis larval density.

In the midsouth, high populations of first generation Heliothis spp. larvae may also develop on crimson clover, Trifolium incarnatum. This early-season legume is frequently included in the seed mixtures used by State and County Highway Departments to establish roadside vegetation. The Southern Field Crop Insect Management Laboratory and the Mississippi State Highway Department are cooperating in research to identify species of legumes less suitable than crimson clover as hosts for Heliothis spp. yet compatible with roadside management practices.

The following six species of legumes were selected for evaluation: crimson clover; red clover (T. pratens L.); white clover (T. repens L.); ball clover (T. nigrescens L.); subterranean clover (T. subterraneum L.); and vetch (Vicia sativa L.). Two grasses frequently included in roadside seed mixtures, fescue (Festuca elatior L.), and bermudagrass (Cynodon dactylon Pers.) were also included in the study. Each of these grasses was sown separately in 0.2 ha plots with and without nitrogen and each, without nitrogen, in a mix with one of each of the six previously mentioned species of legumes for a total of 16 treatments. Of the 16 possible combinations, only those containing crimson clover, ball clover or red clover were infested with Heliothis spp. larvae. Of all the Heliothis larvae collected in all treatments, 88.64% were collected in the two treatment containing crimson clover (56.82% in crimson + bermuda and 31.82% in crimson + fescue); 6.82% were collected in the two treatments containing ball clover (4.55% in ball clover + bermuda and 2.27% in ball clover + fescue); and 4.54% were collected in the two treatments containing red clover (2.27% in red clover + bermuda and 2.27% in red clover + fescue). All of the above larvae were identified as the BW. The Heliothis larval populations in the legume bermuda treatments were higher than those in the legume fescue treatments. All the major pests and beneficial arthropod populations occurring in the above treatments were also sampled but results at this time are incomplete.

In the Delta of Mississippi, Geranium dissectum is a major host plant of the first larval generation of Heliothis spp. and is found in roadside and field margins. The first generation of Heliothis spp. developing in G. dissectum was reduced by 54.2% with four applications of NPV + B.t. + Gustol®, 45.6% with one scheduled mowing, 85.7% with three applications of thiodicarb, 94.3% with three applications of fenvalerate, and 97.1% with one application of 2,4-D. The dynamics and effects of the above control measures on early-season populations of the tarnished plant bug in G. dissectum were also studied. The overwintered population of the tarnished plant bug was active and reproducing by mid-March and at least two generations of plant bugs were produced on this host between late May and early-June. Treating the Geranium spp. with one application of 2,4-D in late-March or mowing Geranium spp. once in mid-April reduced the plant bug population in this habitat by 70.7-71.1% and by 50.4-51.2%, respectively. Three applications of thiodicarb or fenvalerate reduced the population by 50.9% and 77.6-78.5%, respectively. Four applications of NPV + B.t. + Gustol® resulted in a 10% increase in the population.

Hybridization trials continue in an attempt to achieve a male sterile hybrid from crosses of BW and exotic Heliothis species. Heliothis fletcheri, H. armigera, H. gelotopoeon, H. armigera conferta, and H. assulta were received at the Stoneville Research Quarantine Facility. Some crosses have resulted in greatly reduced fecundity in hybrid females, however male or female sterility has not been indicated. Further backcrossing of hybrid progeny is planned and efforts to obtain other species in the bollworm complex continue. (USDA - Stoneville)

New Mexico. Acala 1517-75 (2 separate fields) was treated 3 times at 19 or 23 day intervals beginning on 11 June with one of the following: untreated check, acephate (0.75 lbs(AI)/acre), cypermethrin (0.12 lbs (AI)/acre), or chlordimeform (0.75 lbs (AI)/acre). Comparisons of bloom counts 4-8 weeks after spraying began showed no consistent significant differences among treatments. Similarly, there were no consistent significant differences among treatments with respect to densities (/100 row feet) of either pests (Lygus, cucumber beetles, BW, or thrips) or beneficial arthropods (lacewings, lady beetles, Collops, nabids, minute pirate bugs or big-eyed bugs) over the course of the sampling periods. Lint yields were comparable for all four treatments.

A field test to determine the differences between a pesticide-treated field and an untreated check for mid-season control of BW on Strohman 254 cotton was conducted. The treated field received a combination of mepiquat chloride (1 pt/A), cypermethrin (3 oz/acre), chlordimeform (4 oz/acre) and Penetrator (20 g water/acre). The "check" received mepiquat chloride only. There were no consistent differences between treatment and check in terms of pest (Lygus, cucumber beetles, BW, or thrips) or predator (lacewings, lady beetles, Collops, nabids, big-eyed bugs, minute pirate bugs or spiders) densities. Neither BW eggs nor larvae were significantly reduced by the treatment. Both treated and check plots produced comparable amounts of lint: ca. 3600-3800 lbs/acre. (New Mexico State University)

North Carolina. Third year research (1984-87) into the biology and ecology of the green stink bug focused on the attractiveness and susceptibility of bolls of various age classes to this insect, the effect of feeding time on boll damage and the impact of stink bug

feeding on pathogen transmission, fiber quality and yield loss. With the potential loss of our most effective at-planting insecticide, aldicarb, selected at-planting alternatives were evaluated at various rates in two locations. BW threshold tests (1984-87) continued to strongly support the employment of an egg threshold as the most efficient means of managing larval populations under North Carolina conditions. Research into management systems for European corn borer on cotton (1980-87) pointed to planting date as a second factor (fertility was confirmed earlier) in influencing European corn borer larval populations and subsequent boll damage. Insecticide tests showed biphenthrin to be a highly active and potentially useful compound in controlling this pest; other candidate materials have performed poorly in the past. Thiodicarb at rates varying from 0.25 to 0.6 appeared to be synergized by chlordimeform. Screening tests continued to demonstrate the ability of recommended and promising pyrethroids to effectively control the BW. (North Carolina State University)

Oklahoma. A computer simulation model was generated using zero range interaction with Bose-Einstein speed to illustrate insect movement in a field. This is a continuation of the modeling process developed for immigration into a field with Bose-Einstein statistics. The in-field interaction model was partially verified from two field tests. In the first test, *Hippodamia convergens* Guerin-Meneville, convergent lady beetle, and 12-spotted lady beetles movements were monitored. In the second test, cotton fields with insect populations at equilibrium were disrupted by spraying insecticides and the time required for a return to stability was shown to be short. The timing of movement in the first test validates the assumption that interaction of insects on a minor habitat (in this case, a plant) move in direct relationship to how many other insects are on that plant. The enormous cost in resource to collect insect movement data has led to investigations on improved methods for monitoring insect movement. A preliminary model for computer monitoring insect movement has been developed.

One hundred fifty lines in 11 families of high tannin cotton were evaluated for tannin content (resistance factor to BW and TBW). At least 37 of these lines show significant percentages of condensed tannins to be developed further. An expert system for cotton insect control has been developed for southwestern Oklahoma. The program is written in LISP and is currently being reviewed by all personnel interested in cotton at Oklahoma State.

In small plot chemical tests for *Heliothis* spp. control, cyfluthrin and chlordimeform (0.025 and 0.125 lb (AI)/acre) and biphenthrin (0.6 lb (AI)/acre) provided the lowest amount of *Heliothis* spp. damage after four applications. (Oklahoma State University)

South Carolina. Small plot field tests with Coker 315 were planted April 17, 1986. Control of *Heliothis* spp. by treating with TD-2221 at 0.5, 1.0, and 1.5 lb (AI)/acre, profenofos at 0.5 and 1.0 lb (AI)/acre, and cypermethrin at 0.05 lb (AI)/acre was evaluated. Boll counts show major differences between treatments prior to August 1, 1986, but rain following the severe drought after Aug. 1 resulted in the loss of bolls so that on Aug. 11, all boll counts were comparable.

Tests of TD-2221 at 0.25 (AI)/acre, thiodicarb at 0.4 (AI)/acre, thiodicarb at 0.4 (AI) + 0.125 (AI) chlordimeform, thiodicarb at 0.2 (AI) + 0.125 (AI) chlordimeform and chlordimeform at 0.125 were evaluated as ovicides. As in the insecticide tests, boll counts in all plots were comparable on Aug. 11, 1986, apparently due to drop of bolls due to the rain following the severe drought.

Growth parameters for BW larvae on artificial diet and Coker 315 were determined at 15.6, 21.1, 26.7, and 32.2°C to assist the prediction of age stratification of *Heliothis* populations on cotton. The regression equation for each instar was calculated from the data.

A subroutine for the cotton plant simulation model, GOSSYM, that distributes *Heliothis* larvae and their damage on the plant, was also developed and is being tested.

Field tests were conducted that demonstrated that BW females, when treated topically with sublethal amounts of permethrin, attracted only 27±18.6% as many males as the untreated females. When trap-captured males were treated topically with sublethal amounts of permethrin, only 2.7±1.7% of the treated were recaptured compared with 8.5±1.9% of the untreated. Efforts to determine if similar effects occurred with foliar applications were inconclusive because repellency of the permethrin confounded the results.

Stink bugs appear to have the potential to be a greater problem in areas where the boll weevil has been eliminated as an economic problem, especially if microbial pesticides are used in a biological control program. Three species have been identified as potential pests; present test results indicate that continuous mid-to-late season infestations of one to two green stink bugs per plant will reduce cotton yield. (USDA - Florence)

In a small-plot field test for *Heliothis* spp. control, chemicals and rates (lb AI per acre) producing significant cotton yield increases compared with the untreated check were fenpropathrin (0.10, 0.20), esfenvalerate (0.03, 0.36), cypermethrin (0.06), biphenthrin (0.06), and cyhalothrin (0.02,).025, 0.03). Yields (lb seed cotton per acre) ranged from 210 for the untreated check to 1774 for biphenthrin.

In a second small-plot field test, four insecticide treatments (cypermethrin, *B.t.*, *B.t.* + chlordimeform, and chlordimeform at 0.06, 12BIU, 12BIU + 0.125, and 0.125 lb AI per acre) were evaluated against *Heliothis* spp. when applied at three thresholds: the Clemson recommended threshold, 0.5 x the recommended threshold, and 1.5 x the recommended threshold. Treatments and thresholds producing significant yield increases compared with the untreated were cypermethrin and chlordimeform (all thresholds), *B.t.* + chlordimeform (0.5 and 1.0 thresholds), and *B.t.* (0.5 threshold). Cypermethrin was the superior treatment at all threshold levels, and *B.t.* was the least effective. No significant differences in yields existed between *B.t.* + chlordimeform and chlordimeform.

Thrips collections from seedling cotton for all varieties recommended for South Carolina (Coker 304, 310, 315; McNair 220, 235; PD 1, 2) revealed that four species, *Frankliniella fusca* (Hinds), tobacco thrips, *F. tritici* (Fitch), flower thrips, *F. occidentalis* (Pergande), western flower thrips, and *Sericothrips variabilis* (Beach), soybean thrips, comprised 59.9, 19.7, 15.1, and 5.3% of the population, respectively. Average population densities for six collection dates were significantly higher for PD-1 than for McNair 220.

Six early-season applications of chlordimeform (0.125 lb AI per acre) to seven cotton varieties produced a highly significant mean yield increase of 6.1%. Increases ranged from 1.9% for PD-1 to 12.3% for McNair 235. (Clemson University)

Tennessee. Eight applications of carbamate, organophosphate, and pyrethroid insecticides were studied for their effect on BW damage, maturity, percent lint at first harvest, and yield. Seasonal mean damage was significantly higher in the untreated check. Damage among treatments was not significantly different except that damage in the cypermethrin + dimethoate treatment was significantly lower than in the thiodicarb treatment. First harvest yields from the sulprofos treatment were significantly lower than from other treatments. Total yield among treatments was not significantly different except that yield from sulprofos- and fenvalerate-treated plots was lower than from thiodicarb-treated plots. All treatments produced more than the untreated check at first and total harvest. Percent first harvest for all treatments except sulprofos was greater than in the untreated check.

New insecticides were evaluated for BW control, and their effect on lint yield and maturity. The untreated plot had more damage than any treated plot. Damage in esfenvalerate-, cyfluthrin-, and cyhalothrin-treated plots was less but not different from any other treatments except chlorpyrifos + permethrin. Yield differences were noted for first and total harvest. Total yield was highest from the biphenthrin-treated plot, but was only different from three other treatments. A general trend of delayed maturity was observed with organophosphate and carbamate treatments.

Scheduled applications (3, 6, and 9) of two pyrethroid insecticides (cypermethrin and esfenvalerate) affected seasonal mean BW damage, maturity, and lint percent, but did not affect first or total harvested yield. Less cotton was picked at first harvest when only three applications were made at 10-day intervals.

Two early-season insect management techniques were compared in two tillage systems. Yield at first harvest, total yield, and maturity were higher in aldicarb-treated plots compared to dicrotophos-treated plots. No differences were noted between tillage systems.

Stink bugs (3/row-meter), on preflowering cotton, reduced the number of blooms on three varieties, but yield was not affected. (University of Tennessee)

Texas. COTFLEX, a whole farm cotton expert system will be field evaluated this spring in the southern Blacklands area. The expert system consists of a series of interacting components called "Advisors." The Pest Management Advisor includes a cotton plant model along with cotton fleahopper, boll weevil and Heliothis models. A data base consisting of insecticide recommendations, economic thresholds, price information, etc., is also included. The system is engineered with an IPM expert providing the interpretation of the model base and the data base. In addition a Crop Mix Advisor, a Marketing Advisor and an Agricultural Policy Advisor will be field evaluated. COTFLEX is a fully integrated expert support system.

High tannin cotton lines continue to be evaluated for the BW and spider mite resistance in the central Texas Blacklands. Glandless, high tannin lines are showing significant levels of tolerance to BW. Work is proceeding to improve agronomic performance of these insect resistance lines.

Spider mite outbreaks following the application of pyrethroids have been linked to the reduction of a predaceous mite (being identified). Aldicarb was evaluated for plant growth response under greenhouse conditions using sterile soil. No growth response was recorded when compared with untreated checks. A synergism study mixing pyrethroids and chlordimeform for tarnished plant bug suppression was shown to be inconclusive. The potato leafhopper, Empoasca fabae (Harris), has been determined to be a pest of seedling cotton in the Texas Blacklands. Feeding interrupts the nutrient transport system causing a delay in fruit formation and a reduction in square retention.

Results from field releases of several newly found Mexican parasites of the boll weevil have been encouraging. Released in isolated plantings in South and Central Texas, these parasites have effected parasitism of 25-50% through the season. The new releases are much more efficacious than Bracon mellitor (Say), the most common native parasite of the weevil.

In South Texas, studies showed decrease in Heliothis egg parasitism as cotton trichomes increased. Likewise, predation by lacewing larvae on Heliothis larvae was negatively related to trichome numbers. On nectariless cottons, egg parasitism was decreased.

At a Rolling Plains location, damaging cotton insect species were related to time of planting. Much heavier numbers of overwintered weevils infested late April cotton than late May. Heliothis were more severe in late May cotton. June cotton was attacked by cotton aphids and cotton fleahopper, these insects being absent in the earlier plantings. A two-year study at this location has shown that, under light boll weevil infestations, the edges of a cotton field, ends and sides, are infested with many more weevil punctures than interior of field. In area-wide sampling programs, examination of edges of the field would be the superior place to look for evidence of the boll weevil.

The physiological effects of the cotton fleahopper and microorganisms attacking cotton have been characterized through ethylene production by the plant. The cotton fleahopper carries precursors for ethylene production by the plant, thus accounting for some of the physiological basis for square abcission. The impact of gossypol on insect growth was characterized. Gossypol has a negative effect on the growth rate of Heliothis. Conversely, gossypol increases the growth rate of the cotton leafworm.

TEXSIM, a pest management computer decision aid that links a cotton plant simulation model with cotton fleahopper and Heliothis simulation models on an IBM PC will be ready for field evaluation this spring in the Brazos River Bottom. The predator component of TEXSIM for eight major insect predators is providing reasonable predictions of Heliothis egg survivorship.

Sampling probabilities for Heliothis have been developed for treatment thresholds used in Texas: 5000 and 8000 worms per acre. In addition, size of sample (25, 50, 100 plants), and degree of accuracy has been elaborated.

Studies on the effects of wind on young cotton plants on the Texas High Plains have indicated sharp reductions in plant growth due to the phenomenon. When wind was eliminated, and systemic insecticides used, increased plant growth was noted. Systemics plus wind produced less leafy growth than plants experiencing no wind, and without systemics. Additionally, very large reductions in overwintered BW pupae, and winter survival, were accomplished on High Plains by fall discing of soil (compared to undisturbed soil).

Field and greenhouse studies were conducted to determine the effects of vegetable oils on residual toxicities of selected insecticides to boll weevils and TBW. Insecticides were applied to cotton at suggested field-use dosage rates. Insects were than caged on treated plants at selected posttreatment intervals, and percent mortality was measured. Compared to the aqueous carrier, the emulsified soybean oil carrier hastened knockdown of boll weevils by each of the following insecticides: the pyrethroid, cyfluthrin; the carbamate, oxamyl; and the organophosphate, azinphosmethyl. Also, mortality of boll weevils from exposure to freshly applied cyfluthrin and oxamyl was increased when these insecticides were applied in soybean oil compared to water. Soybean oil did not significantly affect longevity of efficacy of oxamyl and cyfluthrin against weevils. Conversely, soybean oil reduced longevity of efficacy of azinphosmethyl against weevils. Emulsified soybean oil, without insecticide, had no effect on survival of weevils. Efficacy of the carbamate, thiodicarb, and the pyrethroid, cyhalothrin, against TBW was improved when these insecticides were applied in a non-emulsified cottonseed oil diluent. Under conditions encountered in this study (i.e., high daytime and evening ambient temperatures, occasional rainfall, and heavy dew), non-emulsified cotton seed oil prolonged residual toxicities of thiodicarb and cyhalothrin to TBW, compared to residual toxicities of these insecticides applied in water.

A field study was conducted to evaluate the residual toxicities of thiodicarb/cypermethrin mixtures to TBW larvae on cotton. The following seven treatments were in the study: thiodicarb at 0.6, 0.3 and 0.15 lb (AI)/acre (i.e., 100, 50, and 25% of recommended field-use dosage rates, respectively); cypermethrin at 0.06 and 0.006 lb (AI)/acre (i.e., 100 and 10% of recommended field-use dosage rates, respectively); thiodicarb at 0.3 + cypermethrin at 0.006; and thiodicarb at 0.15 + cypermethrin at 0.006. Insects were caged on treated plants at 20 minutes and 48 hours posttreatment, and percent mortality was measured. Twenty-minute-old residues of thiodicarb at 0.6 lb, thiodicarb at 0.3 lb, cypermethrin at 0.06 lb, and both mixtures were equally toxic to TBW; these treatments were more toxic than thiodicarb at 0.15 lb or cypermethrin at 0.006 lb. Residues (48-h-old) of thiodicarb/cypermethrin (0.3/0.006 lb) were as toxic to TBW as 48-h-old residues of thiodicarb at 0.6 lb or cypermethrin at 0.06 lb. Further, 48-h-old residues of thiodicarb/cypermethrin (0.3/0.006 lb) caused significantly greater larval mortality than thiodicarb at 0.3 lb or cypermethrin at 0.006 lb. Conversely, 48-h-old residues of thiodicarb/cypermethrin (0.15/0.006 lb) were less toxic to TBW than 48-h-old residues of thiodicarb at 0.6 lb, cypermethrin at 0.06 lb, or thiodicarb/cypermethrin (0.3/0.006 lb). Thus, a tank-mix of thiodicarb (at 50% of recommended rate) plus cypermethrin (at 10% of recommended rate) may provide

control of Heliothis spp. on cotton equal to either of these insecticides applied alone at full rates recommended for control of this pest. (Texas A&M University)

Table 1. Estimated damage to cotton in the USA by arthropod pests with consequent cost of control and yield loss. (Prepared February 16, 1987).

Table 1a. All States

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	4093256	2639313	1.5	3.06	1.93	189339
Boll/budworms	7218574	4575047	1.8	6.16	2.20	216738
Fleahoppers	5077138	2023242	0.2	2.60	0.86	84811
Lygus bugs	3753867	1721531	0.2	5.26	0.80	79008
Leaf perforator	736150	200700	0.0	7.80	0.01	1909
Pink bollworm	461975	341700	0.0	8.31	0.21	20836
Spider mites	2934741	1125309	0.2	8.42	0.37	37036
Thrips	5233604	2914768	0.4	2.69	0.27	26644
Armyworms	1472287	443536	0.0	9.87	0.02	2483
Minor pests	3350076	2606529	0.3	3.25	1.03	101466
New pests	467815	226700	0.0	4.25	0.01	1122

Acreage harvested: 9270502 Yield per acre: 1.06 Bales
Percent lost: 7.76 Dollars lost: 219,282,688 Cost per acre: 24.70

Table 1b. North Alabama

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	208200	200000	6.7	1.40	8.69	18525
Boll/budworms	208200	208200	4.0	4.60	4.22	8999
Fleahoppers	0	0	0.0	0.00	0.00	0
Lygus bugs	208200	85000	0.4	0.80	0.32	699
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	175000	78000	0.3	5.10	0.30	642
Thrips	208200	208200	2.0	2.85	1.00	2142
Armyworms	115000	100001	0.4	6.50	0.09	205
Minor pests	208200	180000	1.7	0.90	0.17	370
New pests	70000	0	0.0	**.**	0.00	0

Acreage harvested: 207000 Yield per acre: 1.03 Bales
Percent lost: 14.82 Dollars lost: 9,096,635 Cost per acre: 40.66

Table 1c. South Alabama

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	138800	138800	8.0	1.40	14.00	20241
Boll/budworms	138800	138800	7.0	4.60	5.00	7229
Fleahoppers	0	0	0.0	0.00	0.00	0
Lygus bugs	138800	1388	0.0	0.80	0.00	1
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	138800	27760	0.2	5.10	0.04	57
Thrips	138800	138800	2.0	2.85	1.00	1445
Armyworms	30000	6500	0.0	6.50	0.02	33
Minor pests	138800	130000	1.8	0.90	0.28	406
New pests	138800	130000	0.9	3.50	0.04	67

Acreage harvested: 138800 Yield per acre: 1.04 Bales
Percent lost: 20.39 Dollars lost: 8,491,322 Cost per acre: 55.39

Table 1. Continued.

Table 1d. North Arkansas

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	85400	55400	0.4	2.00	0.32	900
Boll/budworms	256900	126000	0.9	3.50	0.98	2730
Fleahoppers	45000	5000	0.0	1.60	0.00	5
Lygus bugs	256900	110000	0.4	1.60	0.42	1191
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	130000	25000	0.1	4.00	0.04	135
Thrips	256900	120000	0.7	1.50	0.46	1300
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	256900	10000	0.0	1.60	0.00	16
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 256900 Yield per acre: 1.08 Bales
Percent lost: 2.25 Dollars lost: 1,808,352 Cost per acre: 6.70

Table 1e. South Arkansas

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	180000	160000	3.0	4.35	1.50	3500
Boll/budworms	160000	160000	6.0	6.35	3.00	7000
Fleahoppers	180000	0	0.0	**.**	0.00	0
Lygus bugs	180000	60000	0.3	2.50	0.03	87
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	80000	5000	0.0	4.10	0.00	7
Thrips	180000	16000	0.2	3.15	0.02	46
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	180000	100000	0.9	0.00	0.06	145
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 160000 Yield per acre: 1.46 Bales
Percent lost: 4.62 Dollars lost: 3,106,740 Cost per acre: 52.97

Table 1f. Arizona

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	80000	40000	1.1	9.00	0.05	400
Boll/budworms	200000	80000	0.5	10.00	0.27	2000
Fleahoppers	50000	10000	0.0	9.00	0.00	2
Lygus bugs	240000	180000	1.2	9.00	0.74	5400
Leaf perforator	220000	120000	0.8	9.00	0.12	900
Pink bollworm	270000	260000	1.7	9.00	2.60	18850
Spider mites	180000	100000	0.6	10.00	0.13	1000
Thrips	275000	30000	0.1	7.00	0.02	150
Armyworms	100000	80000	0.5	9.00	0.08	600
Minor pests	100000	80000	0.8	9.00	0.02	200
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 290000 Yield per acre: 2.50 Bales
Percent lost: 4.06 Dollars lost: 8,496,720 Cost per acre: 70.55

Table 1g. California

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	0	0	0.0	0.00	0.00	0
Boll/budworms	0	0	0.0	0.00	0.00	0
Fleahoppers	0	0	0.0	0.00	0.00	0
Lygus bugs	900000	395880	0.4	12.50	2.74	59464
Leaf perforator	10150	0	0.0	**.**	0.00	0
Pink bollworm	20300	18000	0.1	10.00	0.03	772
Spider mites	900000	270000	0.4	13.75	1.06	23175
Thrips	0	0	0.0	0.00	0.00	0
Armyworms	300000	150000	0.1	14.50	0.00	32
Minor pests	120000	37000	0.0	12.50	0.00	0
New pests	1800	0	0.0	**.**	0.00	0

Acreage harvested: 1010000 Yield per acre: 2.15 Bales
Percent lost: 3.85 Dollars lost: 24,031,918 Cost per acre: 15.48

Table 1. Continued.

Table 1h. Florida

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	21500	20500	3.8	5.00	5.72	1716
Boll/budworms	21500	21500	9.0	8.75	5.50	1650
Fleahoppers	0	0	0.0	0.00	0.00	0
Lygus bugs	18000	2200	0.1	8.00	0.10	30
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	200	150	0.0	7.50	0.00	0
Thrips	18000	11000	0.5	8.50	1.02	307
Armyworms	10000	8000	1.1	8.50	1.67	502
Minor pests	0	0	0.0	0.00	0.00	0
New pests	75	0	0.0	**.**	0.00	0

Acreage harvested: 21500 Yield per acre: 1.40 Bales
Percent lost: 14.02 Dollars lost: 1,211,829 Cost per acre: 112.58

Table 1i. Georgia

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	200000	190000	7.0	4.00	9.30	17301
Boll/budworms	200000	200000	7.3	5.75	4.10	7637
Fleahoppers	50000	10000	0.0	3.55	0.01	23
Lygus bugs	50000	20000	0.1	3.29	0.03	72
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	30000	25000	0.1	7.08	0.06	127
Thrips	150000	150000	0.7	4.21	0.07	146
Armyworms	10000	8000	0.0	9.55	0.12	235
Minor pests	120000	30000	0.3	3.25	0.01	29
New pests	50000	30000	0.3	10.19	0.31	587

Acreage harvested: 190000 Yield per acre: 0.98 Bales
Percent lost: 14.06 Dollars lost: 7,534,476 Cost per acre: 79.80

Table 1j. Louisiana

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	570000	564000	6.9	2.90	5.73	38981
Boll/budworms	570000	530000	5.5	6.10	5.30	36000
Fleahoppers	473000	162137	0.2	2.37	0.11	772
Lygus bugs	436105	162337	0.2	2.37	0.11	773
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	248404	106268	0.1	6.38	0.06	430
Thrips	357321	183000	0.3	2.45	0.17	1221
Armyworms	23175	16600	0.0	10.00	0.00	19
Minor pests	412308	224779	0.3	3.16	0.15	1071
New pests	103640	23200	0.0	5.33	0.01	82

Acreage harvested: 570000 Yield per acre: 1.19 Bales
Percent lost: 11.68 Dollars lost: 22,854,142 Cost per acre: 59.19

Table 1k. Missouri

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	10000	0	0.0	**.**	0.00	0
Boll/budworms	60000	20000	0.3	7.60	0.62	1197
Fleahoppers	20000	0	0.0	**.**	0.00	0
Lygus bugs	80000	21000	0.1	4.00	0.26	503
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	10000	2000	0.0	4.00	0.02	47
Thrips	30000	21000	0.2	4.00	0.26	503
Armyworms	10000	0	0.0	**.**	0.00	0
Minor pests	15000	2000	0.0	7.00	0.01	23
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 160000 Yield per acre: 1.20 Bales
Percent lost: 1.18 Dollars lost: 655,500 Cost per acre: 4.70

Table 1. Continued.

Table 1l. Mississippi Delta

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	370245	325845	2.2	1.56	1.78	15940
Boll/budworms	759645	724391	4.9	5.25	5.33	47776
Fleahoppers	624500	161000	0.2	1.24	0.07	674
Lygus bugs	680645	488391	1.3	2.78	0.74	6695
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	378200	274700	0.9	7.11	0.69	6206
Thrips	742095	707841	1.7	1.37	0.76	6807
Armyworms	461000	34500	0.0	4.85	0.03	337
Minor pests	616600	550100	1.1	3.00	0.97	8690
New pests	83500	41500	0.1	1.29	0.03	317

Acreage harvested: 766130 Yield per acre: 1.17 Bales
Percent lost: 10.43 Dollars lost: 26,912,634 Cost per acre: 46.01

Table 1m. Mississippi Hill

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	219547	218047	6.1	1.52	4.86	10856
Boll/budworms	213407	192724	3.7	4.58	3.40	7604
Fleahoppers	174058	22780	0.1	0.74	0.03	81
Lygus bugs	187467	96635	0.8	1.90	0.58	1314
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	400	600	0.0	4.00	0.00	21
Spider mites	124499	49800	0.3	5.90	0.23	523
Thrips	207708	178177	1.4	1.94	0.94	2101
Armyworms	187512	3910	0.0	6.68	0.04	90
Minor pests	188498	133725	0.9	2.40	0.45	1023
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 222092 Yield per acre: 1.00 Bales
Percent lost: 10.58 Dollars lost: 6,801,712 Cost per acre: 35.49

Table 1n. New Mexico

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	0	0	0.0	0.00	0.00	0
Boll/budworms	67500	27700	0.8	9.80	3.25	2775
Fleahoppers	37500	18750	0.6	8.25	1.19	1015
Lygus bugs	27750	16700	0.5	7.30	1.19	1017
Leaf perforator	1000	700	0.0	10.00	0.01	9
Pink bollworm	21275	8100	0.3	9.33	0.64	548
Spider mites	2500	100	0.0	10.00	0.00	2
Thrips	75000	13500	0.4	8.20	0.98	840
Armyworms	1500	500	0.0	12.50	0.04	40
Minor pests	400000	250000	3.9	2.85	99.20	84635
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 63000 Yield per acre: 1.35 Bales
Percent lost: **.** Dollars lost: 26,175,357 Cost per acre: 36.04

Table 1o. North Carolina

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	0	0	0.0	0.00	0.00	0
Boll/budworms	85000	85000	3.5	7.00	2.52	2125
Fleahoppers	0	0	0.0	0.00	0.00	0
Lygus bugs	85000	0	0.0	**.**	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	4250	0	0.0	**.**	0.00	0
Thrips	85000	21250	0.2	2.50	0.05	42
Armyworms	3400	0	0.0	**.**	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 84000 Yield per acre: 1.00 Bales
Percent lost: 2.58 Dollars lost: 624,240 Cost per acre: 25.42

Table 1. Continued.

Table 1p. Oklahoma

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	60000	55000	0.6	3.75	0.77	1604
Boll/budworms	250000	150000	1.8	8.75	1.80	3750
Fleahoppers	250000	100000	0.4	3.75	0.60	1250
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	10000	0	0.0	**.**	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	75000	35000	0.2	9.00	0.01	29
Thrips	0	0	0.0	0.00	0.00	0
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 250000 Yield per acre: 0.83 Bales
Percent lost: 3.18 Dollars lost: 1,910,400 Cost per acre: 22.24

Table 1q. South Carolina

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	35000	0	0.0	**.**	0.00	0
Boll/budworms	113000	90000	3.1	6.25	3.18	2392
Fleahoppers	50000	575	0.0	**.**	0.00	1
Lygus bugs	55000	2000	0.0	4.00	0.01	13
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	10000	500	0.0	8.00	0.00	0
Thrips	113000	40000	0.3	2.00	0.35	265
Armyworms	70000	25000	0.6	11.00	0.44	332
Minor pests	50000	15000	0.2	4.50	0.00	0
New pests	20000	2000	0.0	5.50	0.08	66

Acreage harvested: 113000 Yield per acre: 0.66 Bales
Percent lost: 4.09 Dollars lost: 884,913 Cost per acre: 29.52

Table 1r. Tennessee

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	38234	20621	0.3	5.00	0.52	1890
Boll/budworms	229042	77732	0.4	7.00	1.97	7125
Fleahoppers	1000	0	0.0	**.**	0.00	0
Lygus bugs	200000	75000	0.2	3.00	0.47	1718
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	34488	13531	0.0	4.00	0.00	7
Thrips	300000	100000	0.3	2.50	0.31	1145
Armyworms	200	25	0.0	4.00	0.00	0
Minor pests	38770	3925	0.0	3.00	0.02	89
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 315000 Yield per acre: 1.15 Bales
Percent lost: 3.31 Dollars lost: 3,449,656 Cost per acre: 6.80

Table 1s. Texas - Area 1

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	14000	3500	0.0	4.00	0.07	16
Boll/budworms	70000	25000	0.6	10.00	1.71	390
Fleahoppers	70000	3000	0.0	4.00	0.03	7
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	0	0	0.0	0.00	0.00	0
Thrips	70000	21000	0.2	4.00	0.21	49
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 73000 Yield per acre: 0.31 Bales
Percent lost: 2.03 Dollars lost: 133,425 Cost per acre: 8.35

Table 1. Continued.

Table 1t. Texas - Area 2

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	0	0	0.0	0.00	0.00	0
Boll/budworms	2000000	650000	0.6	9.00	1.54	15572
Fleahoppers	1500000	400000	0.1	5.00	1.52	15333
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	250000	30000	0.0	8.00	0.00	0
Thrips	1000000	800000	0.3	4.50	0.76	7666
Armyworms	150000	10000	0.0	9.00	0.00	47
Minor pests	125000	700000	0.3	3.75	0.33	3354
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 2100000 Yield per acre: 0.48 Bales
Percent lost: 4.17 Dollars lost: 12,088,800 Cost per acre: 9.64

Table 1u. Texas - Area 3

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	450000	200000	0.8	5.30	3.46	14895
Boll/budworms	150000	60000	0.2	9.00	0.40	1718
Fleahoppers	200000	100000	0.1	4.00	0.02	114
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	0	0	0.0	0.00	0.00	0
Thrips	30000	7000	0.0	4.00	0.00	2
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	40000	0.0	0.00	0.00	11
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 750000 Yield per acre: 0.57 Bales
Percent lost: 3.89 Dollars lost: 4,821,877 Cost per acre: 7.21

Table 1v. Texas - Area 4

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	10000	500	0.0	4.50	0.00	0
Boll/budworms	40000	20000	0.4	6.50	1.25	1031
Fleahoppers	80000	40000	0.4	4.00	0.90	750
Lygus bugs	10000	5000	0.0	5.00	0.02	23
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	5000	500	0.0	5.50	0.00	0
Thrips	80000	60000	1.3	3.00	0.34	281
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 88000 Yield per acre: 0.94 Bales
Percent lost: 2.52 Dollars lost: 600,750 Cost per acre: 9.20

Table 1w. Texas - Area 5 & 9

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	150000	5000	1.1	5.00	3.84	312
Boll/budworms	15000	15000	3.4	7.00	11.53	937
Fleahoppers	15000	10000	0.7	5.00	3.84	312
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	0	0	0.0	0.00	0.00	0
Thrips	15000	2000	0.1	5.00	0.76	62
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 13000 Yield per acre: 0.62 Bales
Percent lost: 20.00 Dollars lost: 468,000 Cost per acre: 34.61

Table 1. Continued.

Table 1x. Texas - Area 6

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	500000	3000	0.0	1.50	0.00	23
Boll/budworms	600000	380000	1.2	4.50	1.90	8906
Fleahoppers	568000	400000	0.6	0.60	8.66	40625
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	200000	0	0.0	**.**	0.00	0
Pink bollworm	150000	55000	0.1	3.00	0.13	644
Spider mites	20000	5000	0.0	6.00	0.00	0
Thrips	600000	10000	0.0	5.40	0.00	7
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 600000 Yield per acre: 0.78 Bales
Percent lost: 10.71 Dollars lost: 14,459,625 Cost per acre: 6.79

Table 1y. Texas - Area 7

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	220000	10000	0.1	6.00	0.05	62
Boll/budworms	220000	100000	1.0	7.50	5.00	6250
Fleahoppers	220000	150000	1.5	1.25	11.25	14062
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	200000	0	0.0	**.**	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	10000	2000	0.0	15.00	0.05	62
Thrips	0	0	0.0	0.00	0.00	0
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	220000	35000	0.1	1.25	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 200000 Yield per acre: 0.62 Bales
Percent lost: 16.35 Dollars lost: 5,886,000 Cost per acre: 10.79

Table 1z. Texas - Area 8

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	23080	2000	0.1	4.00	0.06	10
Boll/budworms	23080	7000	0.4	8.00	0.45	76
Fleahoppers	23080	15000	1.3	3.50	0.64	109
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	10000	5000	0.2	10.00	0.10	18
Thrips	23080	20000	0.8	3.50	0.00	0
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 23080 Yield per acre: 0.73 Bales
Percent lost: 1.27 Dollars lost: 61,950 Cost per acre: 13.76

Table 1aa. Texas - Area 10

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	4250	2100	0.0	4.25	0.01	15
Boll/budworms	91000	78500	2.3	8.75	1.57	2269
Fleahoppers	96000	91000	0.9	1.65	0.09	131
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	0	0	0.0	0.00	0.00	0
Thrips	67000	31000	0.3	1.75	0.03	44
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 99500 Yield per acre: 1.45 Bales
Percent lost: 1.71 Dollars lost: 708,921 Cost per acre: 23.03

Table 1. Continued.

Table 1bb. Texas - Area 11

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	50000	40000	3.2	4.00	8.00	5625
Boll/budworms	50000	30000	1.2	4.50	3.00	2109
Fleahoppers	20000	20000	0.4	1.10	4.00	2812
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	0	0	0.0	0.00	0.00	0
Thrips	0	0	0.0	0.00	0.00	0
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	10000	5000	0.1	2.00	0.50	351
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 50000 Yield per acre: 1.41 Bales
Percent lost: 15.50 Dollars lost: 3,138,750 Cost per acre: 18.84

Table 1cc. Texas - Area 12

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	250000	200000	3.2	6.00	4.00	12500
Boll/budworms	250000	250000	1.0	6.00	1.00	3125
Fleahoppers	150000	150000	0.6	2.00	0.60	1875
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	80000	80000	0.6	6.00	0.32	1000
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	50000	50000	0.4	5.00	0.20	625
Thrips	5000	5000	0.0	5.00	0.02	62
Armyworms	500	500	0.0	6.00	0.00	6
Minor pests	150000	75000	0.3	6.00	0.30	937
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 250000 Yield per acre: 1.25 Bales
Percent lost: 6.44 Dollars lost: 5,797,800 Cost per acre: 34.25

Table 1dd. Texas - Area 13

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	35000	35000	6.0	4.75	10.00	7656
Boll/budworms	35000	35000	8.0	13.25	25.00	19140
Fleahoppers	10000	4000	0.1	4.50	0.22	175
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	15000	0	0.0	**.**	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	18000	18000	1.5	5.25	5.14	3937
Thrips	35000	0	0.0	**.**	0.00	0
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	5000	0.0	0.00	0.00	109
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 35000 Yield per acre: 2.19 Bales
Percent lost: 40.51 Dollars lost: 8,933,400 Cost per acre: 143.79

Table 1ee. Texas - Area 14

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	170000	150000	3.5	4.99	6.17	16362
Boll/budworms	140000	91000	1.0	5.97	2.67	7090
Fleahoppers	170000	150000	1.7	3.00	1.76	4675
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	50000	2000	0.0	**.**	0.00	0
Thrips	170000	20000	0.1	2.50	0.00	0
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 170000 Yield per acre: 1.56 Bales
Percent lost: 10.61 Dollars lost: 8,100,840 Cost per acre: 29.59

Table 1. Continued.

Table 1ff. Texas - All Areas

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	1876330	651100	0.5	5.31	1.89	57480
Boll/budworms	3684080	1741500	0.8	7.80	2.26	68619
Fleahoppers	3122080	1533000	0.4	2.56	2.67	80983
Lygus bugs	10000	5000	0.0	5.00	0.00	23
Leaf perforator	495000	80000	0.0	6.00	0.03	1000
Pink bollworm	150000	55000	0.0	3.00	0.02	644
Spider mites	413000	112500	0.0	5.87	0.15	4643
Thrips	2095080	976000	0.2	4.18	0.27	8176
Armyworms	150500	10500	0.0	8.85	0.00	54
Minor pests	505000	860000	0.1	3.87	0.15	4764
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 4451580 Yield per acre: 0.68 Bales
Percent lost: 7.47 Dollars lost: 65,200,138 Cost per acre: 12.56

Table 1gg. Virginia

Pest	Acres infested	Acres treated	No. insecticide applications	Cost per application	% yield reduction	Bales lost
Boll weevils	0	0	0.0	0.00	0.00	0
Boll/budworms	1500	1500	2.0	13.00	10.00	125
Fleahoppers	0	0	0.0	0.00	0.00	0
Lygus bugs	0	0	0.0	0.00	0.00	0
Leaf perforator	0	0	0.0	0.00	0.00	0
Pink bollworm	0	0	0.0	0.00	0.00	0
Spider mites	400	0	0.0	**.**	0.00	0
Thrips	1500	0	0.0	**.**	0.00	0
Armyworms	0	0	0.0	0.00	0.00	0
Minor pests	0	0	0.0	0.00	0.00	0
New pests	0	0	0.0	0.00	0.00	0

Acreage harvested: 1500 Yield per acre: 0.83 Bales
Percent lost: 10.00 Dollars lost: 36,000 Cost per acre: 26.00

Table 2. Recommended additions of insecticides and miticides for cotton pest control for the 1987 crop year.

State	Product	lb (AI)/acre	Target Pest
Alabama	Kelthane		spider mites (deleted)
Arkansas	Di-Syston	0.6-1.0	thrips
	Swat	0.25	aphids
	Thimet	0.5	thrips
	Azodrin	0.1	thrips, plant bugs
	EPN	0.5	boll weevil
	Malathion RTU	0.8-1.0	boll weevil
	Vydate	0.25	boll weevil
California	Under review		
Georgia	Mavrik	0.055-0.1	bollworms
Mississippi	a/		
New Mexico	Larvin	0.6-0.9	beet armyworm
	Curacron	0.5	cotton aphid
N. Carolina	Mavrik	0.06	bollworms
	Methyl parathion	0.5	stink bugs
	Larvin	0.6	bollworms, beet armyworms
	Larvin	1.0	fall armyworms
Oklahoma	Thiodan	0.375-0.75	cotton aphid
	Curacron	1.0-1.5	bollworms
	Mavrik	0.05-0.1	bollworms
	Kelthane	1.0-1.5	spider mites (deleted)
S. Carolina	Mavrik	0.055-0.1	bollworms
	Comite	0.5-1.0	spider mites
Tennessee	Lorsban	0.19	plant bugs (increased)
	Lorsban	0.25-0.5	aphids
	Kelthane	1.0	spider mites (deleted)
Texas	Larvin	0.9	beet armyworm
	Curacron	0.5	aphids
	Swat	0.18-0.25	aphids
	Lorsban	0.25-0.5	aphids
	Lorsban	0.19-0.5	cotton fleahopper
	Sevin		bollworms (deleted)
	Systox		all pests (deleted)

a/ It is recommended that use of pyrethroids on cotton be restrained during early season (planting to ca. first bloom) to avoid selection for pyrethroid resistant tobacco budworm genotypes. For late season use, it is recommended that full labeled rates of pyrethroids should be used in combination with chlordimeform or other insecticides, and applications carefully timed. In addition, mixing pyrethroids with other recommended tobacco budworm materials will aid in controlling pyrethroid resistant tobacco budworm and secondary pests.

Table 3. Promising experimental or registered compounds evaluated in small plot and field tests.

State	Compound or product	lb (AI)/acre	Target pest
Arizona	avermectin (Avid)	0.1-0.2	Carmine spider mite
	hexythiazox (Savey)	0.125-0.25	Carmine spider mite
	MO70894	0.5-1.0	Carmine spider mite
	fenpropathrin (Danitol)	0.2	Carmine spider mite
	cyhalothrin (Karate)	0.02-0.03	pink bollworm
	esfenvalerate (Asana)	0.030-0.036	pink bollworm
	cyfluthrin (Baythroid)	0.033	pink bollworm
	cyhalothrin (Karate)	0.025	tobacco budworm
Arkansas	cyhalothrin (Karate)	0.0025-0.02	plant bug
	biphenthrin (Capture)	0.05	boll weevil
	cyfluthrin (Baythroid)	0.022-0.033	boll weevil
	cyhalothrin (Karate)	0.015-0.03	boll weevil
	esfenvalerate (Asana)	0.015-0.03	bollworms
California	propargite (Comite)	1.25	spider mites
	acephate (Orthene)	0.5	spider mites
	thuringiensin (Dibeta)	0.1	spider mites
	avermectin (Avid)	0.01	spider mites
	bisclofentezin (Apollo)	0.25-0.5	spider mites
	hexythiazox (Savey)	0.125-0.25	spider mites
	methyl parathion	1.0	spider mites
	methomyl (Lannate, Nudrin)	0.9	spider mites
	chlordimeform (Galecron Fundal)	0.25-0.5	spider mites
	permethrin (Pounce, Ambush)	0.2	spider mites
	multi-methyl alkenol (Stirrup-M)	0.25	spider mites
	PH-70-23	0.187-0.25	spider mites
	dicofol (Kelthane)	1.0	spider mites
	oxythioquinox (Morestan)	0.5	spider mites
	bipehenthrin (Capture)	0.1	spider mites
	methamidophos (Monitor)	0.5	spider mites
	chlorpyrifos (Lorsban)	0.5	spider mites
Georgia	hexythiazox (Savey)	0.0625-0.125	spider mites
	biphenthrin (Capture)	0.04-0.06	bollworms, weevils
	cyhalothrin (Karate)	0.015-0.03	bollworms, weevils
	TD-2221	0.5-1.0	bollworms, weevils
	esfenvalerate (Asana)	0.03	bollworms, weevils
Louisiana	SD-115110	0.2-0.4	spider mites, bollworms [a]
Mississippi	TD2215		boll weevil
N. Carolina	cyhalothrin (Karate)	0.02-0.04	bollworms
	biphenthrin (Capture)	0.04-0.06	European corn borer
Oklahoma	esfenvalerate (Asana)	0.03-0.036	bollworms
Tennessee	esfenvalerate (Asana)	0.036	bollworms
	cyfluthrin (Baythroid)	0.033	bollworms
	biphenthrin (Capture)	0.05	bollworms
	Bacillus thuringiensis (Javelin)	1.0	bollworms
	cyhalothrin (Karate)	0.015-0.02	bollworms
Texas	CME 13406	0.03-0.06	boll weevils
	beta exotoxin (Dibeta)	0.066	spider mites
	avermectin (Avid)	0.0075-0.015	spider mites
	phosphamidon (Swat, Dimecron)	0.25-0.5	thrips, aphids
	cyhalothrin (Karate)	0.02-0.025	thrips, aphids, fleahoppers, bollworms, weevils
	esfenvalerate (Asana)	0.03	bollworms

[a] Poor aphid and boll weevil control were observed at each rate.

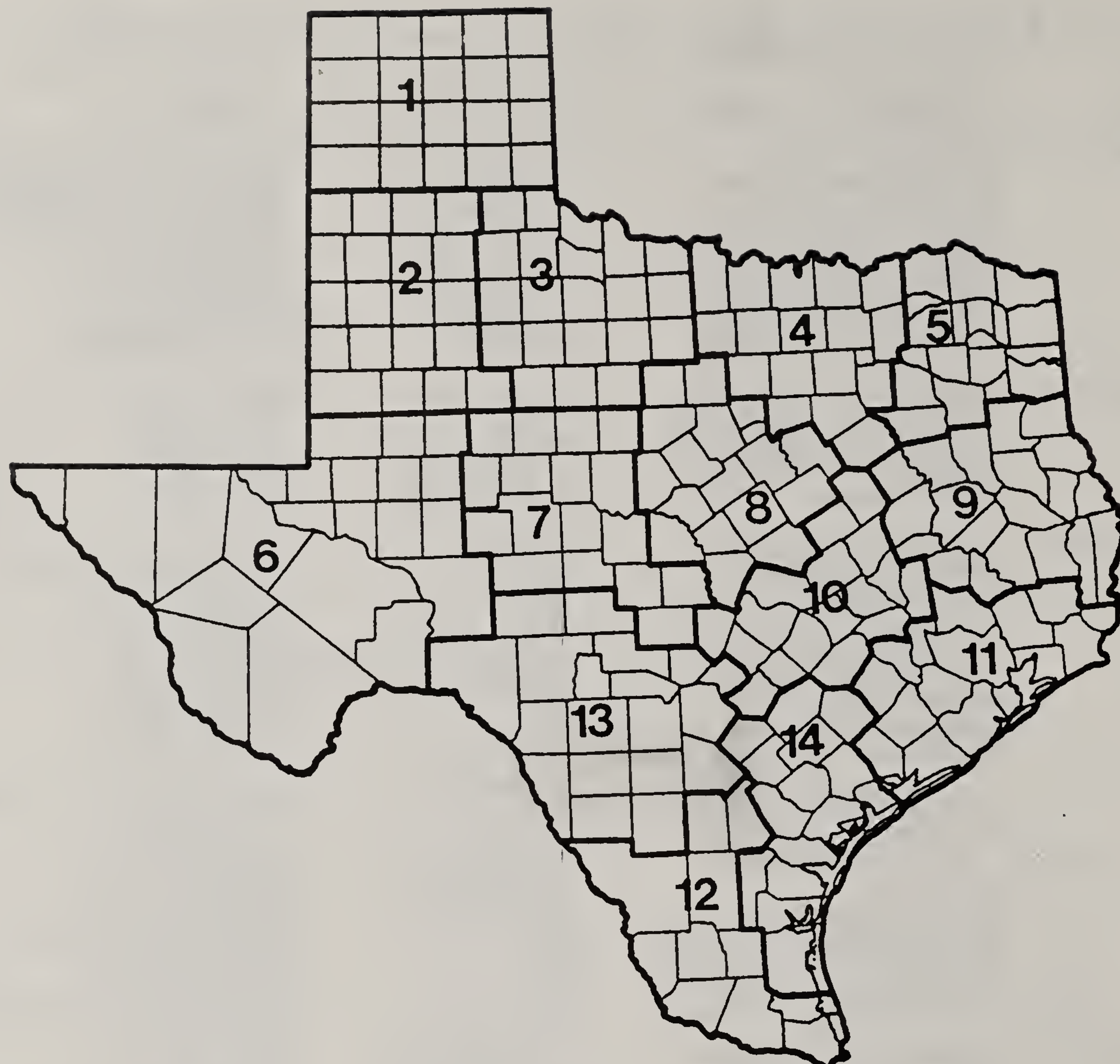

Fig. 1. Areas in Texas relating to Table 1 for estimating the damage to cotton in the USA by arthropod pests with consequent cost of control and yield loss.